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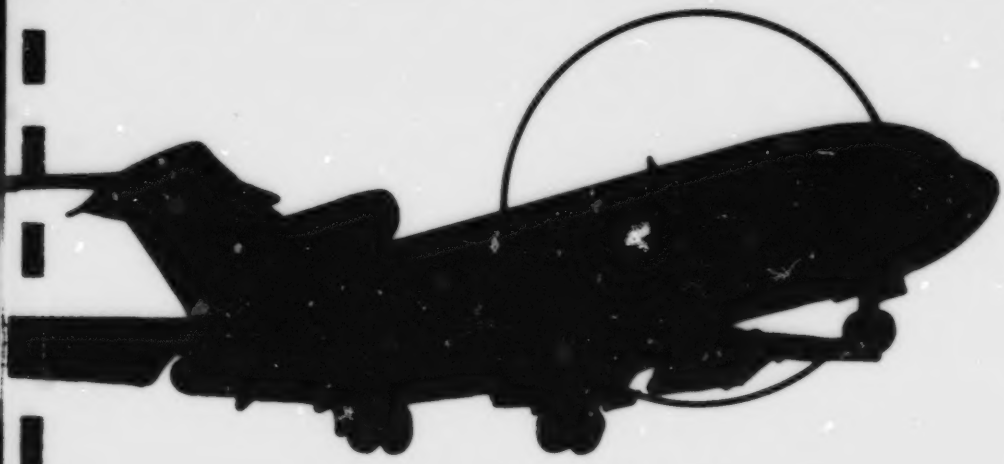

SMALL AIRCRAFT CRASHWORTHINESS

VOLUME I

AN OVERVIEW OF NORTH AMERICAN RESEARCH AND DEVELOPMENT

Prepared for
Transportation Development Centre
by
SYPHER:MUELLER International Inc.
Aerodevco Consultants Inc.

July 1987

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By

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LANGUAGE NOTICE

Un sommaire en français de ce rapport est inclus avant la Table des matières.

Transport Canada Transports Canada
Development Développement

REPORT DOCUMENTATION FORM

1. Transport Canada Report No. TP 8655E	2. TDC Project No. 6784/85/86	3. Recipient's Catalogue No.
4. Title and Subtitle Small Aircraft Crashworthiness (two volumes)		5. Report Date July 1987 6. Performing Organization Report No.
7. Author(s) Robin Lee Monroe, Walter McLeish		8. Transport Canada File No. D1455-183
9. Performing Organization Name and Address SYPHER: MUELLER International Inc. 130 Slater Street Suite 1025 Ottawa, Ontario K1P 6E2		10. DSS File No. 11SD.T8200-6-6527-A 11. DSS or Transport Canada Contract No. T8200-6-6527/01-SD
12. Sponsoring Agency Name and Address Transportation Development Centre 200 Dorchester Blvd. West Suite 601, West Tower Montreal, Quebec H2Z 1X4	Airworthiness Branch Aviation Group, Centennial Towers 200 Kent Street Ottawa, Ontario K1A 0N8	13. Type of Report and Period Covered 14. Sponsoring Agency Code
15. Supplementary Notes Volume I: An Overview of North American Research and Development Volume II: Reference Data Base, Program & User Guide		16. TDC Project Officer W.S.C. McLaren

17. Abstract

Volume I of this study reviews past accident investigations, regulatory developments and crashworthiness research activities for small aircraft in Canada and the United States. From this analysis and extensive interviews, "gaps" or areas where further research and development would be beneficial are identified. A proposed R&D program, which would contribute to the enhancement of the safety of small aircraft and which would be seen to comprise a meaningful Canadian contribution to joint aeronautical research and development efforts between the United States and Canada, is outlined.

Volume II of this report comprises a bibliographic data base on small aircraft crashworthiness, incorporating over 1300 references, and a user guide. The data base program is totally menu driven and allows specific references to be extracted by keyword.

18. Key Words Small Aircraft, General Aviation, Accidents, Crashworthiness, Airworthiness, Survivability, Bibliography		19. Distribution Statement Copies available from the Transportation Development Centre	
20. Security Classification (of this report) Unclassified	21. Security Classification (of this page) Unclassified	22. No. of Pages Vol. I 100 Vol. II 82	23. Price —

TDC CDT 79-005 Rev 86

Canada

Transports Canada Transport Canada
Développement Development

FORMULE DOCUMENTAIRE DU RAPPORT

1. N° du rapport Transports Canada TP 8655E	2. N° de l'étude — CDT 6784/85/86	3. N° de catalogue du destinataire
4. Titre et sous-titre Small Aircraft Crashworthiness (two volumes)		5. Date du rapport Juillet 1987 6. N° du rapport de l'organisme exécutant
7. Auteur(s) Robin Lee Monroe, Walter McLeish		8. N° de dossier Transports Canada D1455-183
9. Nom et adresse de l'organisme exécutant SYPHER: MUELLER International Inc. 130, rue Slater Suite 1025 Ottawa (Ontario) K1P 6E2		10. N° de dossier — ASC 11SD.T8200-6-6527-A 11. N° de contrat — ASC ou Transports Canada T8200-6-6527/01-SD
12. Nom et adresse de l'organisme parrain Centre de développement des transports 200 ouest, boul. Dorchester Suite 601, Tour ouest Montréal (Québec) H2Z 1X4	Direction navigabilité Groupe aviation, 200, rue Kent, Tours Centennial Ottawa (Ontario) K1A 0N8	13. Genre de rapport et période visée 14. Code de l'organisme parrain
15. Remarques additionnelles Volume I: An Overview of North American Research and Development Volume II: Reference Data Base, Program & User Guide		16. Agent de projet — CDT W.S.C. McLaren

17. Résumé

Le tome I du rapport de recherche sur la résistance à l'écrasement des petits avions au Canada et aux Etats-Unis traite des enquêtes antérieures sur les accidents, ainsi que de l'évolution de la réglementation applicable et des travaux de R&D réalisés dans ce domaine. Cette analyse et des entrevues exhaustives ont permis de mettre en évidence des lacunes et de cerner les secteurs où l'accroissement de la R&D serait bénéfique. Ce rapport propose un programme de R&D débouchant sur une sécurité accrue des petits avions et qui constituerait une participation intéressante du Canada aux efforts déployés dans ce domaine des deux côtés de la frontière.

Le tome II du rapport renferme un recueil de données sur la résistance à l'écrasement des petits avions, comportant plus de 1 300 références, ainsi qu'un guide des utilisateurs. Ce recueil se présente sous la forme d'un programme informatique dont l'exploitation est facilitée grâce à un menu d'interrogation, et la récupération des données accélérée par l'utilisation de mots clés.

18. Mots-clés Petits avions, aviation générale, accident, résistance à l'écrasement, navigabilité, aptitude à survivre, bibliographie.		19. Diffusion S'adresser au Centre de développement des transports	
20. Classification de sécurité (de ce rapport) non classifié	21. Classification de sécurité (de cette page) non classifiée	22. Nombre de pages Volume I 100 Volume II 82	23. Prix —

CDT/TDC 79-005 Rev 86

Canada

SMALL AIRCRAFT CRASHWORTHINESS

AN OVERVIEW OF NORTH AMERICAN RESEARCH AND DEVELOPMENT

EXECUTIVE SUMMARY

Prior to 1970, no mechanism existed to coordinate aeronautical research and development (R&D) between Canada and the United States. This resulted in a certain amount of duplication and an absence of sharing in areas of common interest.

To address this situation, the Volpe-Jamieson agreement between the Federal Aviation Administration (FAA) and Transport Canada was signed in 1970. The purpose of this agreement was to allow for the joint identification of areas where each country excelled or had the potential to excel in particular areas of aeronautical research and development, to exchange information and ultimately to avoid costly duplication. The Volpe-Jamieson agreement covered aeronautical R&D in telecommunications, navigational aids and air traffic control. In 1980, an Annex to the Volpe-Jamieson agreement was signed, expanding the provisions to encompass all areas of civil aeronautics including airworthiness.

Crashworthiness research and development continues to be undertaken in both countries. Although a great part of the R&D in this area has been focussed on transport category aircraft, increasing public awareness of the significant number of general aviation accidents and ensuing legal actions has raised the profile of the crashworthiness of small aircraft, particularly in the United States.

Concurrent with U.S. efforts, Canadian interest in small aircraft crashworthiness R&D has been re-kindled. Recommendations of the Commission of Inquiry into Aviation Safety and a desire to contribute to U.S./Canada aeronautical R&D have been significant factors. Over 95% of the Canadian fleet falls within the small aircraft category, and increasingly, aircraft accident analyses have pointed to the probability that many of the fatalities and serious injuries experienced could have been prevented through improved crashworthiness.

The objectives of the study were to review the existing status of North American research and development in small aircraft crashworthiness, to identify gaps or areas where further R&D would be beneficial, and to propose R&D program areas which would not only contribute to the enhancement of the safety of small aircraft but also be seen to comprise a meaningful Canadian contribution to joint aeronautical research and development efforts between the United States and Canada.

To achieve these objectives, the report reconstructs the chronology of crashworthiness regulations, provides an outlook on future regulations in this area and outlines the implications of U.S. regulatory developments on Canadian requirements. Small aircraft crashworthiness R&D activities in both the U.S. and Canada are also synthesized with a particular emphasis

placed on recent (post 1980) developments. In addition, existing accident investigation analyses carried out in support of small aircraft crashworthiness R&D are examined.

Since 1985, the extent of ongoing research and development work in the United States has slowed, although it is clear when talking to the principal researchers that much remains to be done. Superficially, the volume of published material suggests it would be difficult to identify gaps in small aircraft crashworthiness R&D, but under scrutiny the gaps began to appear.

Six areas or "gaps" were identified in the course of this study as potential subjects of focus for future R&D. These areas include: research into the applicability of existing crash dynamics data including computer simulation/modelling; systems approach/coordination; retrofit; composites; post-crash survival; and fuel systems (post-crash fire).

From the Canadian perspective, it was concluded that Canada did indeed have an interest in small aircraft crashworthiness R&D and should to the extent possible contribute to international efforts in this area. It was also a concensus that initiatives pursued should, if possible, be in areas of primary "Canadian" interest. Consequently the "gaps" in R&D serve as a basis to re-examine which areas would be of particular value to Canada or areas where there is existing Canadian R&D capability to build on.

The six areas identified as "gaps" (primarily by U.S. researchers) were evaluated in light of the concerns expressed by the government, industry and institutional researchers interviewed in Canada. The factors considered in identifying potential program areas for small aircraft crashworthiness R&D were as follows:

- The general aviation fleet comprises approximately 95% of the total number of aircraft in Canada. Most types are certificated under CAR 3;
- The high cost of replacement aircraft and the financial situtation of private operators and small air carriers makes it highly unlikely that newer aircraft will replace the existing ones in the near future;
- Small aircraft in Canada, more often than in the U.S., operate in sparsely settled regions;
- The conditions in which small aircraft operate in Canada are more severe than those in the U.S.;
- The likelihood of small aircraft accidents occurring in inaccessible areas is higher in Canada than in the U.S.;
- The Canadian Aviation Safety Board (CASB) and other government agencies have, to some degree taken environmental considerations into the development of existing programs, e.g., ELT, R&D;

- Transport Canada as a regulatory body has a requirement to draw upon R&D and engineering work specifically related to special Canadian conditions;

- Pockets of small aircraft crashworthiness R&D expertise exist in Canada; and

- Canada is in a position to facilitate coordination of R&D because it has no vested interest such as a domestic general aviation manufacturing industry, and associated litigation history.

Taking these factors into consideration, two primary potential candidate program areas for Canadian initiative in small aircraft crashworthiness R&D were identified:

1. Retrofit/Partial Retrofit

2. Post-Crash Survival

In addition to these areas, there exists considerable university-based R&D experience in the field of computer simulation. This expertise is primarily housed at the University of Toronto's Institute for Aerospace Studies. A more detailed assessment of this expertise could result in the inclusion of this as an additional potential program area.

The report offers recommendations in three areas - overall "general" recommendations, recommendations with respect to potential program areas, and institutional recommendations. These are as follows:

GENERAL

1. It is recommended that Canada, in the interests of improving safety of general aviation aircraft, increase its contribution to international R&D in the area of small aircraft crashworthiness.

R&D PROGRAM AREAS

1. A general aviation crashworthiness R&D program should be set up in Canada.

2. Retrofit and/or post-crash survival R&D should be the primary focus of work to be undertaken in Canada.

3. A benefit/cost analysis should be carried out to ascertain the impact upon safety of undertaking each R&D program.

4. Prior to program delineation, the FAA and/or other appropriate U.S. agencies should be consulted with respect to their future plans in these areas.

INSTITUTIONAL

1. The National Aeronautical Establishment (NAE) of the National Research Council of Canada (NRC) should become the lead agency for small aircraft crashworthiness R&D.

2. Transport Canada/TDC should sponsor a small aircraft crashworthiness workshop to explore the development of a Canadian crashworthiness R&D program.

3. Transport Canada should sponsor a Standing Committee under the aegis of an NRC Associate Committee to review and coordinate long-term Canadian crashworthiness activities.

4. Transport Canada/TDC should dedicate funds for crashworthiness R&D.

5. The NAE with the assistance of the proposed Crashworthiness R&D Associate Committee should develop a program to monitor the U.S. R&D agencies other than the FAA.

6. Transport Canada should review the Volpe-Jamieson Agreement and its amendments to determine if it is appropriate for a TC-FAA cooperative approach into small aircraft crashworthiness whereby each agency would agree to take a lead role in specific gaps in small aircraft crashworthiness R&D.

7. The CASB should explore with the U.S. National Transportation Safety Board the development of a compatible accident reporting system.

8. Industry cooperation through associations such as the Air Industries Association of Canada (AIAC) should be considered.

RÉSISTANCE À L'ÉCRASEMENT DES PETITS AVIONS

TOUR D'HORIZON DE LA R&D EN AMÉRIQUE DU NORD

SOMMAIRE

Jusqu'en 1970, il n'y avait aucun mécanisme susceptible de coordonner la R&D se faisant au Canada et aux États-Unis en matière d'aéronautique, de sorte qu'il existait une situation de double emploi ou d'absence de collaboration.

L'entente Volpe-Jamieson conclue en 1970 entre la Federal Aviation Administration (FAA) des États-Unis et Transports Canada (TC) visait à: identifier les secteurs de R&D en aéronautique que chaque pays dominait le mieux ou était bien placé pour dominer, procéder à des échanges d'informations et, en fin de compte, éviter le double emploi si coûteux. Cette entente englobait les applications aéronautiques des télécommunications, les aides à la navigation aérienne et le contrôle de la circulation aérienne. En 1980, un avenant a été signé, portant sur la généralisation de l'entente à tous les aspects de l'aéronautique civile, y compris la résistance à l'écrasement.

Bien qu'elle ait surtout été axée sur les aéronefs de transport, il y a depuis peu un certain alignement de la recherche sur la survie des petits avions civils, spécialement aux États-Unis où l'opinion publique est de plus en plus consciente, répercussions juridiques aidant, du nombre croissant d'accidents en aviation générale.

Au Canada, l'intérêt pour la R&D dans ce domaine a été relancé en même temps, principalement sous l'impulsion donnée par la Commission d'enquête sur la sécurité aérienne, suite au désir d'une plus grande participation au programme aéronautique É.-U./Canada. D'autre part, plus de 95 p. 100 des aéronefs canadiens appartiennent à la catégorie des petits avions et, de plus en plus, les enquêtes sur les accidents d'avions montrent que, dans de nombreux cas, les dommages corporels en ayant résulté, fatals ou non, auraient pu être évités si les aéronefs avaient été plus résistants.

La présente étude avait pour but de passer en revue l'état de la R&D sur la résistance des petits avions fabriqués en Amérique du Nord, de mettre en évidence les créneaux oubliés et de cerner les secteurs où une R&D accrue serait bénéfique; également, de proposer un programme de R&D débouchant sur une sécurité accrue tout en constituant une participation intéressante du Canada aux efforts déployés dans le domaine aéronautique des deux côtés de la frontière.

Dans cette optique, le présent rapport fait l'historique de la réglementation applicable, esquisse un aperçu de la réglementation future et souligne les conséquences du resserrement prévu dans la réglementation aux États-Unis sur les conditions minimales exigées au Canada. En outre, il résume les actions de R&D lancées dans ce domaine des deux côtés de la frontière, en insistant sur les plus récentes (à partir de 1980). Enfin, il passe revue les analyses d'accidents d'avions dans le cadre de travaux de R&D en matière de résistance à l'écrasement des petits avions.

L'ampleur de la R&D aux États-Unis n'a cessé de décroître depuis 1985, bien que, de l'avis des principaux établissements de recherche, beaucoup reste encore à faire. La masse des documents de recherche publiés sur ce sujet est telle que, à première vue, on peut avoir l'impression que tout a été couvert dans ce domaine; toutefois, cette impression se dissipe dès que l'analyse se fait plus serrée, laissant apparaître les lacunes.

En effet, notre étude a décelé pas moins de six secteurs ou créneaux pouvant intéresser la R&D. Ce sont: mise à profit des connaissances dans le domaine des forces dynamiques en jeu lors d'un écrasement, par simulation ou modélisation sur ordinateur; approche systémique; rattrapage; matériaux composites; capacité de survie; circuits d'alimentation carburant (prévention d'incendies post-écrasement).

L'étude de la situation canadienne a montré que le Canada avait tout intérêt à approfondir la question de la résistance des petits avions et qu'il devrait participer, dans toute la mesure du possible, aux programmes internationaux de R&D dans ce domaine; elle a également montré que les actions lancées par notre pays devraient, autant que faire se peut, porter sur des points d'intérêt primordialement canadien. Par conséquent, les six créneaux mis en évidence ne constituent qu'un point de départ pour la détermination des secteurs de recherche les plus profitables pour le Canada ou, du moins, de ceux où les compétences canadiennes sont déjà établies.

Les six secteurs ou créneaux qualifiés d'intéressants par des chercheurs surtout américains ont été évalués à la lumière des besoins exprimés par les milieux canadiens autorisés: gouvernement, avionneurs et institutions de recherche. Les facteurs pris en compte ont été les suivants:

- Près de 95 p. 100 des aéronefs immatriculés au Canada appartiennent à la catégorie aviation générale et ont une certification CAR 3.

- Le coût élevé de remplacement conjugué à la situation financière des exploitants privés et des petits transporteurs fait que le rajeunissement du parc dans un avenir rapproché est plus qu'improbable.

- Plus qu'aux États-Unis, les petits avions sont exploités ici dans des régions à faible densité de population.

- Les conditions d'exploitation des petits avions sont plus rigoureuses au Canada qu'aux États-Unis.

- La probabilité qu'un accident de petit avion se produise dans une région reculée est plus élevée ici que là-bas.

- Les organismes canadiens concernés - le Bureau canadien de la sécurité aérienne (BCSA), par exemple - ont tous, dans une certaine mesure, pris en compte les facteurs d'environnement particuliers pour l'élaboration de leur programme respectif. Exemple: les radiobalises de détresse, la R&D, etc.

- À titre d'autorité de réglementation, Transports Canada a le devoir de faire appel à des travaux de R&D ou à des techniques applicables aux conditions particulières du Canada.

- Il existe au Canada des compétences plus ou moins étendues en matière de R&D sur la résistance à l'écrasement des petits avions.

- Le Canada est en bonne position pour agir à titre de coordonnateur de la R&D en ce domaine du fait qu'il ne compte aucun avionneur exploitant le créneau des petits avions et que les litiges associés à cette fabrication sont donc inexistants.

Tout compte fait, les deux secteurs ou créneaux identifiés comme présentant un intérêt réel pour le Canada ont été les suivants:

1. Rattrapage total ou partiel.

2. Capacité de survie.

De plus, il existe dans les universités canadiennes de grandes compétences reliées au domaine de la simulation sur ordinateur, et notamment à l'Institute for Aerospace Studies de l'Université de Toronto. Une analyse approfondie de ces compétences pourrait déboucher sur la décision de créer un autre secteur de R&D axé justement sur la simulation par ordinateur.

Les recommandations formulées dans le rapport sont de trois ordres distincts: généralités, programmes de R&D et établissements de recherche. Elles préconisent que:

GÉNÉRALITÉS

1. Le Canada, dans l'intérêt d'une sécurité accrue de l'aviation générale, intensifie sa participation aux programmes internationaux de R&D dans le domaine concerné.

PROGRAMMES DE R&D

1. Le Canada lance un programme de R&D sur la résistance à l'écrasement des petits avions.

2. Un programme de R&D soit lancé sur ces deux créneaux particuliers que sont le rattrapage et la capacité de survie.

3. Une étude soit lancée sur le rapport avantages-coût de ces deux programmes et sur leur impact en matière de sécurité accrue.

4. Avant de définir ces deux programmes, la FAA et les autres organismes réglementaires des États-Unis soient consultés quant à leurs intentions futures dans les créneaux concernés.

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1. L'Établissement aéronautique national (EAN) du Conseil national de recherches (CNR) devienne le chef de file des établissements faisant de la R&D dans le domaine de la résistance à l'écrasement des petits avions.

2. Transports Canada et le Centre de développement des transports organisent un atelier où pourra être débattue l'orientation à donner au programme de R&D dans ce domaine.

3. Transports Canada mette sur pied un comité permanent placé sous l'égide d'un comité associé du CNR et chargé d'examiner et de coordonner les actions à long terme dans ce domaine au Canada.

4. Transports Canada et le Centre de développement des transports consentent des fonds à ce programme.

5. L'EAN, avec la collaboration du comité associé proposé, étudie un programme de suivi des actions de R&D lancées aux États-Unis par des organismes autres que la FAA.

6. Transports Canada réexamine l'entente Volpe-Jamieson ainsi que ses avenants afin de déterminer si elle convient à une coopération TC-FAA où ces deux parties se partageraient les créneaux de R&D définis, chacune selon ses compétences propres.

7. Le BCSA étudie avec son homologue américain, le U.S. National Transportation Safety Board, la possibilité d'adopter une procédure de compte rendu d'accident qui soit compatible.

8. La coopération par l'entremise d'associations aéronautiques, comme l'Association des industries aérospatiales du Canada, soit envisagée.

Small Aircraft Crashworthiness
Volume I
An Overview of North American Research and Development

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1. INTRODUCTION

In many areas of aeronautical research and development (R&D), Canada has played a secondary role to the United States. This can be accounted for by a number of reasons, a major one being scale of funding capability.

Prior to 1970 no mechanism existed to coordinate aeronautical R&D carried out in Canada and the United States, resulting in a certain amount of duplication and an absence of sharing in areas of common interest. To address this situation, the Volpe-Jamieson agreement between the Federal Aviation Administration (FAA) and Transport Canada was signed in 1970. The purpose of this agreement was to allow for the joint identification of areas where each country excelled or had the potential to excel in particular areas of aeronautical research and development, to exchange information and ultimately to avoid costly duplication. The Volpe-Jamieson agreement covered aeronautical R&D in telecommunications, navigational aids and air traffic control. In 1980, an Annex to the Volpe-Jamieson agreement was signed, expanding the provisions to encompass all areas of civil aeronautics including airworthiness.

Crashworthiness[1] as an area of research and development is currently being undertaken in both countries. Although a great part of the R&D in this area has been focussed on transport category aircraft, increasing public awareness of the significant number of general aviation accidents and ensuing legal action has raised the profile of the crashworthiness of small aircraft[2] particularly in the United States.

From 1972 to 1981 in the United States 36,500 accidents occurred involving general aviation airplanes. Of the 76,600 occupants of these airplanes, more than 12,500 (16 percent) were killed and more than 6,600 (9 percent) were seriously injured (1). The National Transportation Safety Board's (NTSB) investigations of these accidents found that many of the fatal and serious injuries could have been prevented if the occupants had been using shoulder harnesses and had been seated in energy-absorbing seats. Comparable Canadian aviation accident statistics from 1976 to 1986 show that from a total of 5,386 accidents with 11,491 occupants, more than 1,258 (11.2 percent) were killed and 852 (7.4 percent) seriously injured (2). Although Canada has not carried out comparable analyses of crashworthiness it is probable that many of the fatalities and serious injuries could also have been prevented through improved crashworthiness.

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1 Crashworthiness refers to the capability of a vehicle to protect its occupants

2 Until Amendment 34 dated January 15, 1987 (effective February 17, 1987) Small Aircraft were defined as normal, utility and acrobatic airplanes certificated under 14 CFR 23 and predecessor regulations, having a gross maximum certificated take-off weight of 12,500 lbs or less, that had a passenger seating configuration, excluding pilot seats, of nine seats or less.

Following continuous industry representation to the U.S. government to apply existing crashworthiness technology to small aircraft, the National Transportation Safety Board initiated a multi-year program in October 1981 entitled "General Aviation Crashworthiness Project" (3). The program, which was comprised of three phases was completed in 1985. The purpose of the program was to provide a systematic investigation of general aviation airplane accidents with an emphasis on crashworthiness.

In January 1983, the Federal Aviation Administration (FAA) recognizing that updated safety standards were needed for improvement of the cabin safety and occupant protection design requirements for small airplanes, announced its Small Airplane Airworthiness Review Program.[1] A Notice of Proposed Rulemaking (NPRM) on this subject was released on December 12, 1986.[2]

In Canada, the Commission of Inquiry into Aviation Safety, headed by Justice Charles Dubin (1979), focussed upon the airworthiness of small commercial/corporate aircraft. From the recommendations of the three year inquiry, several major studies were commissioned by Transport Canada. Of specific relevance was a study to develop and recommend Airworthiness Standards for Small Commercial and Corporate Aircraft[3] completed by SYPHER Consultants Inc. for Transport Canada. Among the conclusions and recommendations accepted by the Department was the following:

> "It is recommended that selected crashworthiness requirements of CAR 3 and FAR 135 Appendix A be mandatory for commercial aircraft of less than ten seats by December 31, 1988. Specifically:
>
> CAR 3 (1949) and Sections 14 and 15;
> CAR 3 (1949) and 12 Sections 7;
> CAR 3 (1949) and 13 Section 5; and
> FAR 135 Appendix A Sections 31 and 32".[4]

With over 95% of the Canadian fleet falling into the small (12,500 lbs or less) category, Canada has a special interest in research and development related to the crashworthiness of these aircraft.

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1 Notice No. CE-83-1 (48 FR 4290; January 31, 1983)

2 Notice No. 86-19, Federal Register Volume 51, No. 239.

3 Airworthiness Standards for Small Commercial and Corporate Aircraft SYPHER Consultants Inc. 1984.

4 Airworthiness Standards for Small Commercial and Corporate Aircraft SYPHER Consultants Inc. 1984.

REFERENCES

(1) General Aviation Crashworthiness Project: Phase Two - Impact Severity and Potential Injury Prevention In General Aviation Accidents NTSB Report No. SR-85/01.

(2) Canadian Aviation Safety Board, Accident Data Base.

(3) General Aviation Crashworthiness Project Phase One, National Transportation Safety Board Report NTSB/SR-83/01, June 23, 1983.

2. OBJECTIVE

The purpose of this study is to review the existing status of North American research and development in small aircraft crashworthiness, to identify gaps or areas where further R&D would be beneficial, and to propose a R&D program which would contribute to the enhancement of the safety of small aircraft and be seen to comprise a meaningful Canadian contribution to joint aeronautical research and development efforts between the United States and Canada.

3. STUDY METHODOLOGY AND STRUCTURE

3.1 Introduction

To arrive at the ultimate objective of a developing a proposed R&D program for crashworthiness which would complement U.S. R&D in this area, several basic tasks had to be completed. These tasks and their chronological sequence are schematically depicted in Figure 3-1.

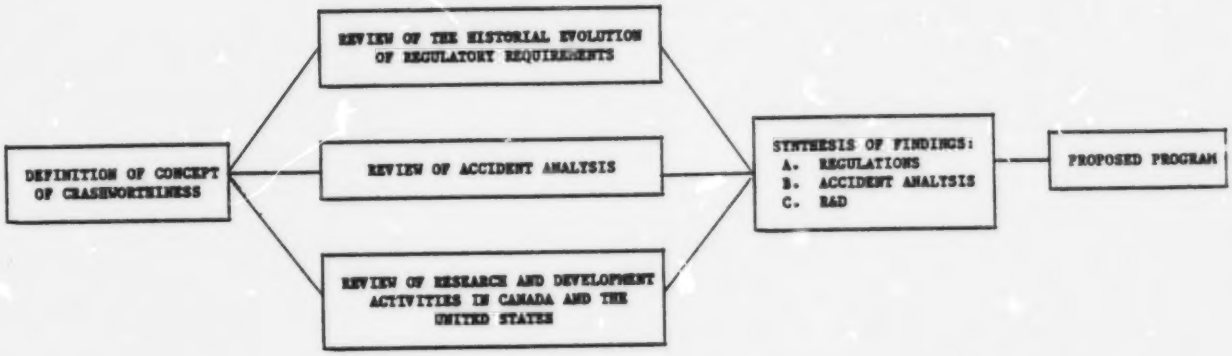

Figure 3-1 Schematic Depiction of Study Methodology Of Small Aircraft Crashworthiness.

After commencing work on this study it became obvious that no one authority or institution in Canada had a comprehensive understanding of what research and development in small aircraft crashworthiness had taken place or who had completed it. There was general knowledge that some significant work had been undertaken in the United States but for the most part no individuals interviewed during this project confessed to having an understanding of the scope of R&D which has been completed, particularly outside very specific areas of interest. In the course of the preliminary interviews it became clear that there was a requirement for a comprehensive synthesis of North American R&D in small aircraft crashworthiness. The volume of literature produced in the United States on this subject also supported the need for a bibliographical data base. Consequently this report is structured in two self contained but related volumes:

Volume I - Small Aircraft Crashworthiness: An Overview of North American Research and Development

Volume II - Small Aircraft Crashworthiness: Reference Data Base, Program and User Guide

3.2 Report Structure

The report structure is reflected in Figure 3-1. The major elements of the report and their rationale are outlined below.

3.2.1 Concept Definition

The term "crashworthiness" was first coined at Cornell University more than thirty years ago. At that time and through today the term is used to describe an aircraft's fitness to "safely" crash - the ability to protect occupants from injury during a survivable type accident.[1]

Unlike the term "airworthy" the term crashworthy is not utilized or defined in regulation - the concept is generally understood and utilized throughout the industry despite the absence of a legal definition. Consequently the first step in this project was to work out with Transport Canada an acceptable definition of the concept of crashworthiness. The second step was to proceed on the basis of that definition to identify the "contributing" elements of crashworthiness.

In a broad sense, it was concurred that crashworthiness includes such considerations as:

(a) maintaining the structural integrity of the fuselage;
(b) attenuating the crash forces acting on the bodies of the occupants;
(c) preventing items of mass from breaking free and becoming injury producing missiles;
(d) providing exits for the escape of occupants after the crash; and
(e) reducing post-crash fire, submersion and other hazardous conditions that may be encountered in an accident.

From the starting point of this general understanding of crashworthiness, subpart, titles and sections of FAR 23, FAR 135 Appendix A and FAR 25 were reviewed for the purposes of identifying areas in the respective regulations where crashworthiness might be addressed. Table 3-1 summarizes the relevant subparts, titles and sections.

3.2.2 Review of Regulatory Requirements

The ultimate objective of research and development in small aircraft crashworthiness, much like that of automobile crashworthiness, is to design a safer more crashworthy vehicle. Generally speaking, the standards and recommended practices to which industry are required to design and construct aircraft are contained in the Federal Aviation Regulations (FARS) and in Advisory Circulars (AC's) respectively. As of July 1982 Canada has adopted

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1 The NTSB definition for "survivable accident" is one in which the forces transmitted to the occupant through the seat and restraint system do not exceed the limits of human tolerance to abrupt acceleration and in which the structure in the occupant's immediate environment remains substantially intact to the extent that a liveable volume is provided througout the crash sequence.

Table 1. Elements of Crashworthiness FAR 23, FAR 135 Appendix A, FAR 25.

SUBPART	TITLE	SECTION FAR 23	SECTION FAR 135 APPENDIX A	SECTION FAR 25
C. Structure	Emergency Landing Conditions	23.561 General		25.561 General
D. Design and Construction	Personnel and Cargo Accommodations	23.771 Pilot Compartment 23.775 Windshields and Windows 23.785 Seats, Berths, Safety Belts and Harnesses 23.787 Cargo Compartments 23.807 Emergency Exits	135.A.1 Cargo and Baggage Compartments 135.A.32 Doors and Exits	25.771 Pilot Compartment 25.775 Windshields and Windows 25.783 Doors 25.785 Seats, Berths, Safety Belts and Harnesses 25.787 Cargo Compartments 25.807 Emergency Exits
	Emergency Provisions			25.801 Ditching 25.803 Emergency Evacuation 25.805 Flight Crew Emergency Exits 25.807 Passenger Emergency Exits 25.809 Emergency Exit Arrangement 25.811 Emergency Exit Marking 25.812 Emergency Lighting 25.813 Emergency Exit Access
	Fire Protection	23.853 Compartment Interiors 23.859 Combustion Heater Fire Protection 23.863 Flammable Fluid Fire Protection	135.A Flammable Fluid Fire Protection	25.851 Fire Extinguishers 25.853 Compartment Interiors 25.859 Combustion Heater Fire Protection 25.863 Flammable Fluid Fire Protection
	Fuel System			25.963 Fuel Tanks-General 25.1189 Shutoff Means
E. Powerplants	Powerplant Fire Protection	23.1189 Shutoff Means 23.1191 Firewalls		
F. Equipment	Safety Equipment	23.1411 General 23.1413 Safety Belts and Harnesses 23.1415 Ditching Equipment		

by reference the Airworthiness Design Standards (FAR's) of the United States. Consequently the evolution and current status of airworthiness requirements related to crashworthiness in the United States is of direct relevance to Canada.

Section 4 of the report will review the chronology of crashworthiness regulations related to small aircraft up to and including the Notice of Proposed Rulemaking (NPRM), published in the Federal Register, FR 44878, Docket No. 25147, on December 12, 1986.

3.2.3 Accident Analysis

Research and development work in crashworthiness is rooted in some form or other in accident analysis. Sections 5 and 6 of this study trace the development of accident analysis in small aircraft crashworthiness. In addition to a description of the historical evolution of major analytical work in this field, it synthesizes the most recent and most comprehensive work to date - that of the NTSB in Phase II and III of the General Aviation Crashworthiness Program.

3.2.4 Review of R&D Activities in Canada and the United States

These sections of the report are comprised of a comprehensive review of the published literature in both Canada and the United States and incorporate information obtained through interviews with key individuals in government, industry and academic sectors in both countries. Sections 7 and 8 provide a synthesis of historical and current R&D in small aircraft crashworthiness. Emphasis has been placed on R&D which has taken place in both countries in the past eight years and culminates with a status report on small aircraft crashworthiness summarized from the Society of Automotive Engineers (SAE) Conference on General Aviation Crash Dynamics held in Wichita, Kansas, April 1987.

3.2.5 Synthesis of Findings - (GAPS Analysis)

Based on the literature review, interviews and research completed in the course of this study. R&D "gaps" or areas where there is concensus for the usefulness/desireability of further R&D will be identified.

3.2.6 Potential R&D Program Initiatives

Based on the analysis and findings of the report and a review of Canadian players' mandates, capabilities and interest, a proposed research and development program to complement that planned in the U.S. will be proposed.

4. CHRONOLOGY OF CRASHWORTHINESS REGULATIONS

4.1 Regulations Prior to 1978[1]

The Air Commerce Act of 1926 assigned to the U.S. Department of Commerce the regulatory responsibility for aviation operations. Through its Aeronautics Branch, the Department of Commerce developed the first Federal airworthiness and other standards for aircraft in the United States. These regulations were known as the Air Commerce Regulations, Bulletin No. 7 (ACR), and became effective on December 31, 1926. Paragraph (A)(3) of Section 15 of the ACR required "Seat belts or equivalent apparatus for pilots and passengers in [an] open cockpit [of aircraft] carrying passengers for hire." This apparently was the first requirement for seatbelts in civil aircraft and also seems to have been the first occupant- protection requirement. This regulation was revised effective June 1, 1928, with the addition to the revised ACR Section 10, paragraph (1)(c) of a requirement that "Seats or chairs in cabin airplanes shall be firmly secured in place."

Aeronautics Bulletin 7A, effective July 1, 1929, established the first restraint strength requirements. In addition to the 1928 occupant-protection requirements, the ACR regulations required that "Safety belts and their attachments shall be capable of withstanding a load of 1,000 pounds applied in the same manner as a passenger's weight would be applied in a crash. The attachment shall be such as to be capable of carrying this load through the main structure."

An expanded ACR, effective January 1, 1931, required in paragraph (C)(3) of Chapter 3, Section 34, Supplies and Equipment:

> Safety belts or equivalent for pilot and passengers in all aircraft. Seats or chairs in cabin aircraft shall be firmly secured in place. Seatbelts and their attachments shall be capable of withstanding a load of 1,000 pounds applied in the same manner as a passenger's weight would be applied in a crash. The attachment shall be such as to be capable of carrying this load through to the main structure.

The ACR was revised and reorganized again effective January 1, 1933; however, the requirements for seats and seatbelts were not changed. Effective March 1, 1933, the airworthiness requirements were separated from the ACR into a new Aeronautics Bulletin No. 7-F, "Airworthiness Requirements for Aircraft Components and Accessories." This bulletin applied to any accessory or component classified as important if, by

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1 Section 4.1 is extracted from NTSB SR-80-2, The Status Of General Aviation Aircraft Crashworthiness, December 17, 1980.

malfunctioning, it could endanger the safety of the aircraft or the cargo or passengers in the aircraft, or persons or property beneath the aircraft. To be approved, the items had to:

1. Satisfactorily fulfill the purpose for which they are intended.

2. Be free from undue hazard, both in themselves and in their method of operation.

3. Be constructed of suitable and dependable materials.

4. Be manufactured and installed in accordance with the air commerce regulations insofar as those regulations pertained to the particular unit.

Paragraph (A) of Section 27, Design Conditions, stated:

> Safety belts for use in airplanes shall be capable of withstanding a load of 1,000 pounds applied in the same manner as a person's weight would be applied in a crash. They shall also be easily adjustable and equipped with a quick-release mechanism capable of being operated by hand under a load of 400 pounds. The quick-release mechanism shall be designed to withstand the required load of 1,000 pounds without undue distortion, so that when the load is relieved to 400 pounds the mechanism may be worked by hand.

A revision of the ACR, effective October 1, 1934, required that the design load of 1,000 pounds should be applied upward and forward at an angle of approximately 45 degrees with the floorline.

Because of the growth and increasing public interest in aviation, the limited safety authority granted by the Air Commerce Act of 1926 was broadened in the Civil Aeronautics Act of 1938. This Act conferred increased authority on the Department of Commerce for regulating aircraft safety and design standards through Civil Air Regulations, and also created an Air Safety Board to enforce air commerce and manufacturer safety boards.

On November 12, 1945, the Civil Aeronautics Board (CAB) published final regulations: 14 CFR 3, "Airplane Airworthiness-Normal Utility, Aerobatic, and Restricted Purpose Categories." Title 14 CFR 3.3811, Emergency Provisions, required that the fuselage be designed to give every reasonable probability that all occupants, if they made proper use of seatbelts or harnesses for which provisions were made in the design, would escape serious injury in the event of a minor crash, although it was accepted that parts of the airplane might be damaged. The minor crash conditions were defined as conditions in which the occupants experience the following ultimate acceleration forces in all combinations:

Acceleration Force Category	Crash Forces by Aircraft Type: Normal Utility (g)	Aerobatic (g)
Upward	0 to 3.0	4.5
Forward	0 to 9.0	9.0
Sideward	0 to 1.5	1.5

Also, 14 CFR 3.3811 required that the fuselage, in combination with other portions of the structure of airplanes having retractable landing gear, be designed to afford protection of the occupants in a wheels-up landing with moderate descent velocity. Additionally, airplanes other than those whose configuration rendered the possibility of turnover remote were required to have a fuselage designed in combination with other portions of the structure to protect the occupants in a complete turnover.

Title 14 CFR 3.3822 required that all seats, berths, and supporting structures be designed for a passenger weight of 170 pounds (190 pounds with parachute for the aerobatic and utility category) and for the maximum load factors corresponding to all specified flight and ground load conditions, including the emergency conditions described in 14 CFR 3.3811. The section also required that pilot seats be designed for the reaction resulting from the application of the forces to the primary flight controls as specified in 14 CFR 3.230.

Title 14 CFR 3.38221, Seat Belt or Harness Provisions, required that provisions be made at all seats and berths designed as occupiable during takeoff and landing for belts or harnesses necessary to comply with the emergency conditions of 14 CFR 3.3811.

Title 14 CFR 3.715, Safety Belts, was revised on January 6, 1950, to require that airplanes manufactured on or after January 1, 1951, be equipped with approved safety belts which provided strength corresponding to the ultimate load factors specified in 14 CFR 3.386. Also, attachments were required to be designed to comply with the ultimate load factors.

On March 8, 1950, the Civil Air Regulations again were revised, and minor changes were made to 14 CFR 3.386, Emergency Provisions. This provision stated:

> "The fuselage shall be designed to give reasonable assurance that each occupant, if he makes proper use of belts or harnesses for which provisions are made in the design, will not suffer serious injury during minor crash conditions as a result of contact of any vulnerable part of his body with any penetrating or relatively solid object, although it is accepted that parts of the airplane may be damaged."

The changes in wording from the requirement that every "reasonable probability" from serious injury be assured through fuselage design to providing "reasonable assurance" reduced substantially the responsibility of airplane manufacturers. The requirements for airplanes with retractable landing gear and for protection in the event of overturn remained unchanged. However, a note was added which stated that a vertical ultimate acceleration of 3 g and a friction coefficient of 0.5 at the ground might be assumed.

On September 27, 1950, in a notice in the Federal Register (page 6500), the CAB proposed that the design strength for seats and berth attachments be increased by a factor of 1.33, i.e., inertial force specified in paragraph 3.386 against which each occupant was to be protected during minor crashes was increased. Also, it was proposed to require that seatbelts be of an approved design.

In April 1951, the CAB published an interpretration of 14 CFR 3.386 which became 14 CFR 3.386-1, Crash Protection. This interpretation stated that cockpit arrangements and cabin structure collapse had been found to cause excessive injuries in crashes. The interpretation was based on close study of crash results which showed that when the human body was properly supported, it could tolerate crash forces that exceeded those necessary to demolish contemporary aircraft structures. The interpretation set out the following points of general significance:

1. Many survivable accidents are fatal because of insufficient design considerations.

2. The torso is rarely exposed to dangerous injury when seatbelts hold and control wheels provide support for the chest.

3. Protection from head injuries, the principal cause of crash fatalities, can be reduced by eliminating, shielding, or redesigning elements in the cabin which permit solid head blows.

In view of the fact that injuries and fatalities in many moderate and severe accidents were purely mechanical results of poor cockpit designs, the CAB included "guide rules for design" as suggestions to aircraft manufacturers. These suggestions included the elimination of projections and sharp edges; anchoring of objects such as compasses; providing flat, yielding surfaces to absorb forces; and strengthening safety belts, because many had failed without causing bruises to the occupant's hip or causing internal injuries.

On September 17, 1953, the CAB published in the Federal Register (page 5563) a supplement to 14 CFR 3.386 which established acceptable methods for applying the required loads to seats and berths in analyses or tests. While the supplement acknowledged that the actual forces consisted of many combinations of forward, sideward, downward, upward, and aft loads, the simplified test procedure permitted the manufacturer to assume that the critical loads acted separately.

The passage of the Federal Aviation Act of 1958 established the Federal Aviation Agency (FAA) and made it responsible for aviation safety. The Civil Air Regulations applicable to crashworthiness were continued unchanged for the next 6 years; however, interpretations of these regulations were frequently issued by the FAA. In the interpretations relative to restraints, the FAA pointed out that:

> The torso is rarely exposed to dangerous injury when the seatbelts hold and control wheels provide reasonable support for the chest. In personal aircraft every consideration should be given to holding the body by adequate safety belt installations, and by the support which can be provided in control wheels and instrument panels... The present "1,000 pound" safety belts have failed in a high percentage of accidents without causing internal injuries or bruising of the hips. In failing they have exposed the pilot to excessive injuries.

On September 28, 1964, the FAA issued a new 14 CFR 23 entitled, "Airworthiness Standards-Normal, Utility, and Aerobatic Category Airplanes," which replaced Part 3 of the Civil Air Regulations and essentially recodified the previous regulations. The stated purpose of this rulemaking action was to rewrite the existing regulations in one writing style throughout - not to change the substance.

The need for shoulder harness protection must have become strongly evident to the FAA since it issued in 1965 Advisory Circular (AC) 43.13-2, "Acceptable Methods, Techniques, and Practices - Aircraft Alterations." This AC has been revised several times, the last time in June 1977. This AC included in Chapter 9, "Shoulder Harness Installations," information about different types of shoulder harness restraint systems, retrofit design considerations, and details on modifications needed for anchorage points for several airframe construction types. Also included was the fact that structural repair kits were available from many manufacturers for establishing necessary anchorage points.

In section 146, General, the AC states that "Basic requirements of the aircraft airworthiness rules are designed to provide an aircraft structure to give each occupant a reasonable chance of escaping serious injury in a crash landing. These requirements adequately provide for conditions that can be expected to occur in various types of survivable accidents." This statement contrasts with the objective stated for shoulder harnesses (not required in the aircraft design) "to prevent incapacitating and/or fatal injuries to personnel involved in a survivable crash condition in which the aircraft structure remained reasonably intact." The AC acknowledged that the FAA had established no standards for shoulder harness materials, attachments, or acceptance tests.

When the Department of Transportation (DOT) was created by the U.S. Congress in 1966, the FAA was placed within the DOT under the administration of the Secretary of Transportation. The agency name was changed to the Federal Aviation Administration.

In 1967, the FAA proposed that 14 CFR 23 be further amended, and proposed (32 FR 5791, April 11, 1967) that the requirments for seats, berths, and belt attachment factors be combined into one section of the regulations which would require either (1) that effective upper torso restraints be installed, (2) that the airplane interior be designed to eliminate injurious objects within the striking radius of the head, or (3) that energy-absorbing support for the upper torso be provided. The explanation given for this action was: "Experience indicates that a significant reduction in injuries and fatalities may be obtained..."

Title 14 CFR 23.785, Seats and Berths, was revised effective September 14, 1969, (34 FR 13078) to require that:

> "Each occupant must be protected form head injury by: (1) A safety belt and shoulder harness that will prevent the head from contacting an injurious object; (2) A safety belt plus the elimination of any injurious object within striking radius of the head; or (3) A safety belt plus an energy-absorbing rest what will support the arms, shoulders, head, and spine."

In the discussion section of this rulemaking, the FAA commented that "the fact that shoulder harnesses were presently available as optional equipment and that they may not be used by some occupants does not negate the need for the rule change." Further, it was pointed out that the FAA had an educational program, Advisory Circular 00-21, and Report AM 66-33 to encourage shoulder harness use.

Effective August 30, 1971, a new FAA rule required that every occupant flying on a U.S.-registered civil aircraft fasten safety belts during takeoff and landing. Even though there had been a requirement for seatbelts for some general aviation aircraft since 1926 and for all general aviation aircraft since 1931 (except during the period 1964-1969), there had never been a legal requirement to use these occupant protection items. This requirement affected some 130,000 general aviation aircraft.

In 1973, the FAA issued a Notice of Proposed Rule Making (NPRM), Docket 10162, "Crashworthiness for Small Airplanes," which proposed to require the installation of shoulder harnesses on all airplanes manufactured after 1 year from the effective date and on small civil airplanes manufactured prior to that date if they had structural provisions for the attachment of shoulder harnesses. Also, this NPRM proposed to require occupants of seats equipped with shoulder harnesses to use them during takeoff and landing. The FAA stated that it believed the proposed shoulder harnesses should reduce the probability of occupant injury in small airplanes and further that additional protection should be provided in the area surrounding each seat within striking distance of the occupants head, torso, and flailing arms and legs. Thus, the FAA proposed a new section 14 CFR 23.785(j), that would require this area be free of sharp edges, protuberances, and hard areas. The NPRM acknowledged that additional suggestions for regulatory change had been made to increase the design "g" force levels, to require that the cockpit or cabin structure remain intact under those impact forces,

to require dynamic testing of seats, and to require further means to reduce potential ignition sources associated with accidents. In response to these suggestions, the FAA stated that its research and development programs and the data and recommendations submitted did indicate possible future courses of action for upgrading the crashworthiness of small airplanes, but present information was not sufficient to support such rulemaking action.

Four and one-half years after its initial proposal, the FAA on June 9, 1977, issued a final rule based on its 1973 NPRM. Except for requiring shoulder harnesses at front seats in aircraft manufactured after July 18, 1978, the FAA rejected the proposal for shoulder harness installations at occupant seats stating that,

> "Based upon an evaluation of the expected benefits and other impacts on the public and private sectors,...the adoption of this amendment will result in a significant improvement in the chances of occupants of small airplanes covered by the amendment to survive minor crash landings and provide those occupants additional protection in more severe crashes at nominal cost. Over the next 25 years, it is estimated that approximately 1,875 lives may be saved by this amendment at an average cost of less than $5.5 million per year."

The final rule, 14CFR 23.785, did require that newly certificated general aviation aircraft be designed to eliminate, within striking distance of an occupant's head or torso, potentially injurious objects, sharp edges, protuberances and hard surfaces. Also, changes made in the final rule to 14 CFR 91.7 require that crewmembers, while at their station during takeoff and landing, keep available shoulder harnesses fastened. This requirement does not apply to a passenger occupying a front seat equipped with a shoulder harness.

4.2 Regulations After 1978

Amendment 22 to 14 FAR 23.1413 in 1978 required safety belts to include metal to metal latches by December 1981.

Appendix A to FAR 135 was introduced in 1979. It provided requirements for safeguarding doors during flight; door openability from inside and outside; signal to crew that doors are closed and locked; number of emergency exits; exit markings; isle widths; power plant; nacelle; and fluid fire protection.

During the next six years following 1979 no crashworthiness regulatory changes occured, however, the FAA continued to undertake a number of initiatives in parallel with its crash dynamics engineering and development program. These included work of the General Aviation Safety Panel (GASP) and the Small Airplane Airworthiness Review Program Conference which produced numerous recommended rule changes which have subsequently given rise to NPRMs, Advisory Circulars and some rule changes. They will be dealt with in order of their promulgation.

In 1983 Advisory Circular 23.807-1 outlined recommended external markings and identification of emergency exits which are openable from outside small airplanes. The following year FAA held the Small Aircraft Airworthiness Review Program Conference at which the GASP recommendations were discussed. The FAA issued an NPRM 84-12 Docket 24191 indicating its intention to standardize cockpit controls.

In 1985 the FAA issued an NPRM 85-11 Docket 23815 dated May 6 which proposed special retroactive requirements for normal, utility, and acrobatic aircraft manufactured one year after the effective date of the proposal to amend FAR 23.785 to include shoulder harness at all passenger seats and to amend FAR 91 to require that shoulder harness be fastened during take-off and landing. The date of June 20, 1985 was stipulated as the closing date for comments. The Amendment 32 dated December 12, 1985 adopted the NPRM 85-11. Next, Amendment 33 adopted NPRM 84-12 to require the standardization of controls.

FAA issued ANPRM 85-7 Docket 24494, March 5, 1985 requesting comments on proposed rules, and based upon its opinion that it would be premature to accurately evaluate the costs and benefits of complying with a proposed rule for crash resistant fuel systems, FAA requested cost estimates from the public on the design, manufacture and installation of such systems. Proposed rule making would depend upon the evaluation of the comments received.

Finally on December 12, 1986 an NPRM 86-19 Docket 25147 announced the FAA's intentions to introduce rules to adopt new and amended airworthiness standards for small airplanes based upon "a number of issues discussed at the Small Airplane Airworthiness Review Conference held in 1984 and the FAA's Crash Dynamics Program". "The proposals of this first notice*, when adopted, will enhance cabin safety and occupant protection by raising the level of safety for new designs of small airplanes type certificated to these new and revised standards." "Comments are due on or before June 12, 1987."

In the background section of the docket, the FAA provided a comprehensive summary of the development of its position in the proposed regulation. The roles of the 1984 Small Airplane Airworthiness Review Program, the GASP, the GAMA, the NTSB, and the FAA specialist offices were described and related to the regulatory and economic evaluations which indicated the costs and benefits of the anticipated prevention of fatalities based upon the expected annual average fatalities derived from the FAA's Accident/Incident Data System.

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* The reference to "First Notice" relates to the "Small Airplane Airworthiness Review Program". Subsequent notices will deal with aircraft systems, propulsion, flight, reliability, etc.

The FAA acknowledged that it was generally agreed that the GASP proposals were technically and economically achievable and if adopted would be a very significant step forward in the enhancement of cabin safety and occupant protection of small airplanes. It further concluded that its first NPRM should concentrate on airworthiness standards for the improvement of cabin safety and occupant protection for small airplanes, and that it has under consideration the adoption of proposed rules for Commuter Category airplanes which will address the issues of cabin safety for such aircraft as was announced in FAR Notice No. 83-17 (48 FR 52010, November 15, 1983).[1]

The specific regulations proposed in Docket 25147 would introduce or amend paragraphs in FAR 23 as follows:

23.561 introduce dynamic loading on the occupant and hence to the seat and supporting structure; higher forward and side load factors on items of mass in occupied cabin areas

23.562 new paragraph on emergency landing dynamic conditions including dynamic seat test

23.783 provides protection against doors being opened in flight plus the capability to open doors from outside and warning to the crew if the door is not fully closed, and anti-jamming criteria.

23.785 amended to increase design loads to 215 lbs per occupant.

23.787 new cargo loads and restraint criteria

23.807 provides emergency exit on side opposite to the entrance door.

4.3 Summary Of U.S. Small Aircraft Crashworthiness Regulations

Table 4-1 contains a comprehensive list of crashworthiness regulations which traces the chronology described in the narrative of the preceding pages. It is structured as a matrix in which the columns identify the regulatory agency, the regulatory code, and specific criteria of crashworthiness according to groups or categories i.e. - seats; belts; harness; emergency landing conditions; crashfire prevention; door & exists; floats and buoyancy; survival equipment. The rows are in order by date.

As of April 1987 the status of FAR 23 requirements for cabin safety and occupant protection is based upon the amendments to FAR 23 as listed in Table 4-2.

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1 FAA adopted new rules for commuter category airplanes effective February 17, 1987 by amendment 23-34 announced in 52 F.R. 1806 dated January 8, 1987.

Table 4-1. List of Crashworthiness Regulations

YEAR	AGENCY	LEGISLATION	SEATS, BELTS HARNESS, STRUCTURE	EMERGENCY LANDING PROVISIONS	EMERGENCY EXITS, DOORS MARKINGS	FIRE PROTECTION FF SHUT-OFF	CARGO	SAFETY EQUIPMENT DRAFTS LIFE PRESERVERS SIGNAL DEVICES	HULLS FLOATS BUOYANCY
1926	Department of Commerce Aeronautics Branch.	Air Commerce Act of 1926 established first federal regulations called Air Commerce Regulations ACR.	Occupant Protection requiring seat belts and secure chairs.						
1927	"			Proposed handbook for airplane design.					
1928	"	ACR Bulletin 14	Chairs to be secured	Aero Bulletin No. 14 for airplane structures, engines and propellers.					
1929		ACR Bulletin 7, 7A, 7C	Occupant protection requiring belts and chairs to transmit 1000 lbs to structure.						
1931	"	ACR Bulletin 7A expanded.	"	Aero Bulletin No. 7 - Basic Rule 7A - Airframe 7C - Engines and Propellers					
1933	Bureau of Air Commerce Department of Commerce.	ACR Bulletin 7F amendment.	Airworthiness Requirements for aircraft components and accessories.						
1934			1000 lbs load to be applied upward and forward at 45° to floor.						
1938	Civil Aeronautics Administration Civil Aeronautics Board.	Civil Aeronautics Act 1938 Civil Aeronautics authority manual (CAAM).	Recodification of ACR.						
1940	Civil Aeronautics Administration Civil Aeronautics Board.	Civil Aeronautics Manual CAM 1940.	Further recodification as CAM.						
1945	"	Civil Aeronautics Regulations CAR 03	(Airplane Airworthiness Requirements for Normal, Utility, Aerobatic and Restricted Purpose Categories)						
1945	"	CAR 03		3.38.11 Emergency Provisions providing for escaping serious injury in minor crash of aircraft with retractable w/c or complete turnover for fixed gear and under specified ultimate acceleration forces.					
1945	"	CAR 03	3.38.22 seats, berths and support structure to provide for 170 lbs. passenger and ultimate acceleration forces of 3.38:1						
1950	"	CAR recodification to CAR 3.							
1950 (Nov)	"	CAR 3		3.386 amended "reasonable probability from serious injury to "reasonable assurance".					
1950 (Sept)	"	CAR 3		3.386 seats belts to be approved design and seat attachment forces amended to 1.33 times the forces previously stated.					

Table 4-1. List of Crashworthiness Regulations (cont'd)

YEAR	AGENCY	LEGISLATION	SEATS, BELTS HARNESS, STRUCTURE	EMERGENCY LANDING PROVISIONS	EMERGENCY EXITS, DOORS MARKINGS	FIRE PROTECTION FF SHUT-OFF	CARGO	SAFETY EQUIPMENT DRAFTS LIFE PRESERVERS SIGNAL DEVICES	HULLS FLOATS BUOYANCY
1950	Civil Aeronautics Board - Civil Aeronautics Administration.	CAR 3 Amendment 4	4-3.390/391			4-3.637			
1951	-	CAA guidance for design	3.386-1	3.390-1 crash protection against poor design including sharp edges, protruding objects.					
1953	-	Federal Register		Supplement to 3.386 provide guidance on applying loads to seats and berths in analysis and test.					
1955	-	CAR 3 Amendment 13		Items that could come loose during minor crash must be restrained to higher acceleration forces (in line with TC requirements).					
1956	-	CAR 3 Amendment 14	Removed the needs for harness and belts for berths.						
1956	-	CAR 3 recodified							3.371(b) removed weight consideration requires a minimum of 4 compartments but sufficient to provide reasonable chance of staying a float after 2
1957	-	CAR 3 Amendment 2							
1958	Federal Aviation Agency-Civil Aeronautics Board.	Federal Aviation Act of 1958.							
1958	-	CAR 3 Amendment 4		Removed chute requirement since previous 7 years experience.					
1962	-	CAR 3 Amendment 7	7 3.390/3.391						
1964	-	FAR 23 (14 CFR 23) replaced CAR 3 (14 CFR 3)	23.785 23.1413	23.56	23.807 23.783 23.1411 23.1557(d) 23.1561	23.853 23.1189	23.787	23.1415	23.751 23.755
1966		Department of Transportation Act.							
1967	Federal Aviation Administration (DOT)	NPRM 32FR7291	Shoulder harness required or elimination injurious objects within striking distance of head.						

Table 4-1. List of Crashworthiness Regulations (cont'd)

YEAR	AGENCY	LEGISLATION	SEATS, BELTS HARNESS, STRUCTURE	EMERGENCY LANDING PROVISIONS	EMERGENCY EXITS, DOORS MARKINGS	FIRE PROTECTION FF SHUT-OFF	CARGO	SAFETY EQUIPMENT DRAFTS LIFE PRESERVERS SIGNAL DEVICES	HULLS FLOATS BUOYANCY
1967	Federal Aviation Administration (DOT)	NPRM 32FR7291	Shoulder harness required or elimination injurious objects within striking distance of head						
1969	FAA	FAR 23 Amendment 7	Shoulder harness required or elimination of injurious objects within striking distance of head, applicable to newly certificated aircraft.						
1971	FAA	FAR 91 Amendment 10	Occupants on U.S. civil registered aircraft required to fasten safety belt during T.O. and landing.		Number, size form, accessibility, ease of operation based on number of occupants.				
1973	FAA	NPRM 73-1 Docket 10162	"CRASHWORTHINESS OF SMALL AIRPLANES" FAA acknowledges receipt of recommendations to increase design "g" levels; cockpit and cabin should remain intact; proposed "g" dynamic seat tests; means to reduce ignition sources. However, R&D not sufficient to support rule-making, but mandatory shoulder harness proposed in one year of effective date and mandatory use during T.O. and landing.						
1974	FAA	Airworthiness Review Program.							
1977	FAA	FAR 23 Amendment 17 and 19	Seat track stop.			Self extinguishing material close to cabin side of fire wall.	Cargo restraint 4.5 g	Safety equipment must be secured to withstand the ultimate inertia forces for emergency crash landing.	
1977	FAA	FAR 23 Amendment 23	Based upon NPRM 73-1 Mandatory shoulder harness in front seats in aircraft manufactured after July 18, 1978. New designs must eliminate injurious objects within striking distance of head.						
1977	FAA	FAR 91	Crew required to fasten shoulder harness during T.O. and landing.						
1978	FAA	FAR 23 Amendment 22	Effective December 81 mandatory for metal to metal latching of safety belts.						

Table 4-1. List of Crashworthiness Regulations (cont'd)

YEAR	AGENCY	LEGISLATION	SEATS, BELTS HARNESS, STRUCTURE	EMERGENCY LANDING PROVISIONS	EMERGENCY EXITS, DOORS MARKINGS	FIRE PROTECTION FF SHUT-OFF	CARGO	SAFETY EQUIPMENT DRAFTS LIFE PRESERVERS SIGNAL DEVICES	HULLS FLOATS BUOYANCY
1979	FAA	FAR 135			Appendix A Introduced				
1980	FAA	FAR 23 Amendment 25				No smoking signs.			
1983	FAA	Notice No. CE 83-1 Docket 23494, Jan. 31, 1983 announcing the small airplane airworthiness review program.							
1983	FAA	Advisory Circular 23.807-1			Size and shape of emergency exits.				
1984	FAA	Small Aircraft Airworthiness Review Program Conference							
1984	FAA	Advisory Circular 23-2				Flammability of various materials.			
1984	FAA	NPRM 84-12 Docket 24191	Standard Cockpit Controls.						
1984	FAA	Advisory Circular 20-107A	Composite aircraft structure.	Impact Dynamics of composite structures.		Flammability of composites.			
1984	FAA	Advisory Circular 23.807-3			Marking and need to open doors from outside.				
1985	FAA	Advisory Circular 21-22 (new numbering system)	Injury Criteria for Human Exposure to Impact.						
1985	FAA	NPRM 85-11 May 6, 1985	Proposed to make shoulder harness mandatory for each occupant (seat) of normal, utility and acrobatic aircraft with 9 or less passenger seats, and to require them to be fastened.						
1985	FAA	ANPRM 85-7 Docket 24494				Crash resistant fuel systems.			
1985	FAA	Advisory Circular 91-62	Use of infant seats in aircraft.						
1985	FAA	FAR 23 Amendment 32 Dec. 12, 1985 effective Dec. 12, 1986. Adopts NPRM 85-11	Mandatory shoulder harness for all seats in newly manufactured aircraft.						
1986	FAA	FAR 23 Amendment 33 Adopts NPRM 84-12	Cockpit control Standarization						
1986	FAA	Advisory Circular 23-4	Static strength substantation of attachment points for occupant restraint system installations.						
1986	FAA	NPRM 86-19 Docket 25147	23.561 introduces dynamic loading on occupant and hence on seat and structure; higher forward and sideward load factors on items of mass in occupied cabin area. Also amendment to 23.785 increasing design loads to 215 lb occupant.	23.562 new paragraph on emergency landing dynamic conditions including dynamic seat tests.	23.783 provides protection against doors being opened in flight plus capability to open door from outside and warning to crew if door not fully closed plus other details re anti jamming. Also 23.807 provides emergency exit opposite side to entrance door.		23.787 new loads and restraints.		

Table 4-1. List of Crashworthiness Regulations (cont'd)

YEAR	AGENCY	LEGISLATION	SEATS, BELTS HARNESS, STRUCTURE	EMERGENCY LANDING PROVISIONS	EMERGENCY EXITS, DOORS MARKINGS	FIRE PROTECTION FF SHUT-OFF	CARGO	SAFETY EQUIPMENT DRAFTS LIFE PRESERVERS SIGNAL DEVICES	HULLS FLOATS BUOYANCY
1986	FAA	Advisory Circular 91-65	Guidance on unapproved seat modification, storage of articles, inspection of seats, shoulder harness and belts, passenger briefing.						
1986	FAA	Draft Advisory Circular 23.562-1	Dynamic evaluation of small aircraft seating device systems.						
1987	FAA	Advisory Circular 20-118A			Emergency Evacuation Demonstration.				
1987	FAA	FAR 23 Amendment 34		Revised to Incredude commuter category aircraft					

Table 4-2. Summary Of The Current Status Of Crashworthiness Requirements FAR 23

DESCRIPTION	AMENDMENT	DATE
Re-Issue FAR 23	Amendment 7	Sept. 1969
Emergency Exits - 23.807(a)	Amendment 10	Sept. 1971
Seats, Belts, Harness Structure		
- Shoulder harness for all seats of (newly manufactured aircraft - 785 (g)	Amendment 32	Dec. 1985
- Stops to retain seats in tracks - 785(i)	Amendment 23	Dec. 1978
- Safety belts & harness must be approved - 785(b)	Amendment 19	July 1977
- Shoulder harness cannot restrict crew functions 785(h)	Amendment 19	July 1977
- Means to store harness when not in use - 785(i)	Amendment 19	July 1977
- Cabin free of injurious objects surrounding each seat within striking distance of head when harness fastened - 785(j)	Amendment 19	July 1977
- Must be approved seat for each occupant - 1307(a)	Amendment 19	July 1977
- Strength of belts and harness and mandatory metal to metal latch device effective Dec. 1981 - 1413	Amendment 22	Dec. 1978
- Shoulder harness for front seats of all aircraft manufactured after July 18, 1987 - 785(g)	Amendment 19	July 1977
- Cockpit control standardization - 781	Amendment 33	August 1986
Fire Protection		
- Lines, fittings, components - 1183	Amendment 29	March 1984
- Shutoff means - 1189	Amendment 29	March 1984
- Nacelle burn through protection - 1193(f)	Amendment 18	May 1977
- Fire detection system requirement - 1203	Amendment 18	May 1977
- No smoking signs - 853(c)	Amendment 23	March 1980
- Shielding of lines in compartments - 853(d)	Amendment 14	December 1973
- Materials on cabin side of firewall - 853(e)	Amendment 23	December 1978
- Combustion Heaters - 859	Amendment 27	November 1980
- Flammable Fluids - 863	Amendment 23	December 1978
Cargo Compartments		
- Load factors, restraint, - 787(b), (c), (d), (e)	Amendment 14	December 1973
- Protection of cargo from lamps - 787(f)	Amendment 17	February 1977
Safety Equipment, Rafts, Life Preservers, Signal Devices		
- Inertia load protection, accessibility - 1411	Amendment 17	February 1977

The amendment list summarized in Table 4-2 indicates that over a period of eighteen years starting with Amendment 7 in 1969, the FAA adopted a series of small rule changes which improved seats, seat tracks, belts, latches, controls, protruding objects, exits, inertia loads, fire protection, and cargo restraint before it adopted shoulder harnesses, except for front seats in aircraft manufactured after July 18, 1978, which it adopted in July 1977.

It is likely that another major amendment can be expected in late 1987 or early 1988 adopting NPRM 86-19 on dynamic testing as recommended by the GASP. However, the status of post crash fire protection is still only at the ANPRM stage and awaits comments before FAA will issue an NPRM.

The post crash fire ANPRM 85-7, Docket 24494, March 5, 1985 stated FAA's opinion that it was premature to issue an NPRM until it could accurately assess the costs and benefits of compliance with a proposed rule for crash resistant fuel systems. FAA therefore requested comments on the proposed rule and cost estimates from the public on the design, manufacture and installation of such systems.

The NTSB has made available its comment on the ANPRM in a letter to the FAA dated July 22, 1985. In fact, the letter presented new findings by the NTSB which differed from its Report AAS 80-2 on fire studies. The NTSB stated:

> "To forestall any misunderstanding, the Safety Board wishes to emphasize several important differences between the 1982 data evaluation presented above and the 1980 fire study: (1) the 1980 study included all types of aircraft, including helicopters, whereas the 1982 data only included airplanes of modern construction, i.e. those airplanes to which this ANPRM is addressed; (2) the 1980 study data were not analyzed for precise impact severity information as were the 1982 data; (3) the injury information in the 1982 data was far more complete, aiding in more precise crashworthiness evaluations than were possible in the 1980 study; and (4) the 1980 study was a macro analysis of computer data while the 1982 data analysis was based on individual accident file analyses.
>
> The Safety Board believes that the predicted four percent reduction in fatalities by averting fires is an absolute minimum based on a conservative analysis of the accidents. The anticipated improvements through other crashworthiness rulemaking efforts, such as the addition of dynamically tested seat/shoulder harness systems and energy absorbing seats, may expand the survivable envelope of general aviation airplane accidents so that more occupants will survive the impact. These anticipated improvements will increase the number of occupants who will be exposed to post-crash fires which further warrants rulemaking in this area."

The NTSB further stated in response to the ANPRM:

> "Information was requested also on "crash resistance limits to be met by the fuel systems, such as crash impact speeds, deceleration forces, etc." Except in the case of fuel tank design, the Safety Board believes that impact severity, crash acceleration loads, and airplane attitudes are not the proper parameters to define design standards for crash-resistant fuel systems. Accident investigations have shown that fuel lines and fittings are likely to break in survivable crashes. Given that fact, fuel systems should be designed so that the locations of the breaks and separations are dictated by design in order to minimize fuel spillage. For example, if an engine is displaced during a crash, the fuel lines are likely to break regardless of the load generated in the crash. With a properly designed system, the location of the break can be controlled, such as by incorporating a self-sealing fitting as the weakest link in the line. When the self-sealing fitting breaks, both ends of the line are sealed, preventing a fuel spill.
>
> As mentioned above fuel tank design is the one area where crash severity is an important design consideration. Fuel tanks can contain large massess of fuel and thus are affected directly by the acceleration loads. To prevent spillage during a crash, fuel tanks would have to be able to withstand large acceleration loads and to resist penetration. The U.S. Army "Crash Survival Design Guide," Volume V, is the best source of information on this subject[1]. It is recognized that Volume V is primarily directed to helicopter design, but many of the concepts are applicable equally to general aviation airplanes.
>
> The Safety Board is pleased to have the opportunity to comment on this ANPRM. We believe that a minimum four percent savings in lives can be achieved with improved crash-resistant fuel systems. This would be a significant safety improvement which warrants this and future related rulemaking efforts by the FAA."

Subsequently, in a further letter from the NTSB to the FAA dated February 5, 1986, it stated in effect that it had conducted a review of spilled fuel and fire related fatalities in survivable general aviation accidents occuring in 1984 and 1985, which was undertaken at the request of the GASP to support its ongoing study of post crash fires in survivable accidents. The data should prove beneficial to the FAA request in a NPRM 85-7 for information related to cost/ benefit analysis.

The GASP crashfire study began in July 1984 and is now referred to as GASP II. The GASP II recommendations are expected to be forwarded in 1987 to the FAA. Thus, the next action by the FAA could be an NPRM or a review similar to the GASP I review in 1984 of dynamic testing.

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1 "Crash Survival Design Guide," January, 1980, Applied Technology Laboratory, U.S. Army Research and Technology Laboratories, Fort Eustis, Virginia 23604.

4.4 Outlook On Regulations

Although there is momentum to adopt the dynamic testing NPRM and to advance the crash fire rule-making process, new small aircraft designs to FAR 23 are rare these days with the slump in small aircraft demand, so the new rules may not be needed urgently.

The question of retrofitting the existing fleet of small aircraft has not yet been resolved. The NTSB recommended that shoulder harness be made retroactive in 1973 and the FAA decided against the proposal in 1978 when it made shoulder harness mandatory for front seats in newly manufactured aircraft. Again, in 1985, when the FAA amended FAR 23 to require shoulder harness at all seats on aircraft with nine or fewer passenger seats, it decided not to adopt a retrofit for the existing fleet. Subsequent to that the Secretary of the DOT requested the FAA to re-examine the question. The FAA contracted with a university to study the cost/benefits and upon receipt of the study the FAA made a recommendation to the Secretary and is awaiting a response. It was not possible to determine the nature of the recommendation or when a response will be forthcoming.

It also was not possible to ascertain the source of the modification or research data utilized for the cost/benefit study. However, at the 1987 SAE Meeting on Small Aircraft Crash Dynamics held at Wichita on 27-30 April, a paper was presented by the Mission Aviation Fellowship (MAF) and the Jungle Aviation & Radio Service (JAARS) who have retrofitted crash protection installations in two types of general aviation aircraft. The cost for each of 120 aircraft was approximately $15,000 and the modifications have received FAA STC approval. The shoulder harness and energy absorbing seats cost about $5,600 for two front seats. The weight penalty was zero because the Cessna seat weighs 8 pounds more than the JAARS seat. The STC work was undertaken by Simula Inc., and Robertson Aviation Inc.

The FAA has a new TSO C114, Torso restraint system which is based upon the SAE Standards AS 804-3 and is in the administrative process for adoption. Two draft aviation circulars are awaiting comment before being processed by FAA. One on analytical crash dynamics techniques AC 23.562-1 is due by 6/12/87 and the other which deals with shoulder harness in small aircraft is due 5/4/87. Another item under consideration by the FAA concerns turnover protection in small aircraft but no deails could be obtained.

Thus, the chronology of regulation of small aircraft crashworthiness is nearing a significant milestone following intense R&D activities in the eighties, but much remains to be done on both in-service aircraft and on the new technology composite aircraft being developed.

4.5 Implications of U.S. Regulatory Development On Canadian Requirements

As of 22 July 1982, Canada adopted by reference the Airworthiness Design Standards (FAR's) of the United States. Consequently, the evolution of airworthiness requirements related to crashworthiness in the United States is of direct relevance to Canada.

In fact, the Airworthiness Standards contained in Chapter 523 of the TC Airworthiness Manual are based on a Part of the U.S. FAR 23. Provision is made in 523 for additional requirements which are Canadian variations based upon Canadian experience including operational, environmental, and administrative aspects.

There is usually a lag in the adoption by Canada of amendments to FAR 23. The procedure for adoption requires Transport Canada to review an amendment to FAR 23, draft its 523 equivalent[1] and consult with industry. The extent of the lag could be influenced by the FAA rule-making process which is usually followed closely by Transport Canada and the Canadian industry. If the published amendment to FAR 23 closely resembles the proposed amendment issued as a Notice of Proposed Rule-Making (NPRM), then the Canadian adoption time period would likely be minimal. On the other hand, if the NPRM and the amendment differ significantly there would no doubt be a much lengthier time period for the 523 amendment.

A further variation in the U.S. and Canadian rule-making relates to the operational rule changes which are needed at times to implement the intent of airworthiness standards for crashworthiness such as mandatory use of seat belts. In the United States the operational FAR's make provision for airworthiness operating standards, and the amendments to the airworthiness and operational FAR's are dealt with either jointly or serially by means of the Federal Register. In Canada the procedure is not as tidy and is likely to foster further delays in the adoption of the necessary operational regulations. A current example relates to amendment 23-34 to FAR 23 published January 15, 1987 which involves a new category for commuter aircraft. The Canadian adoption of the commuter category will likely require amendments to Air Navigation Orders (ANO) which is accomplished separately from 523 amendments.

Another example involves mandatory shoulder harness in small aircraft. The FAR 23 has required mandatory shoulder harness in the front seats of small aircraft manufactured after July 18, 1978. In addition, FAR 91 requires occupants to fasten them during take-off and landing. As well, the FAR 91 effective December 12, 1986 requires shoulder harness in all seats of newly manufactured aircraft with nine or fewer passenger seats and in compliance with FAR 23 785(g) effective December 12, 1985. In Canada 523 has not adopted FAR 23 amendments beyond amendment 31 effective December 28, 1984. Therefore, only small aircraft manufacturered in the U.S. after July 18, 1978 require shoulder harness and only for the front seats. ANO Series 2 No. 2 requires that seat belts or harnesses be fastened during take-off and landing.

In summary, the time lag between amendments to FAR 23 and 523 are significant in the adoption of improved airworthiness requirements for crashworthiness. If the United States does not decide to make the recent amendments for crashworthiness retroactive to older aircraft, then the same situation will prevail in Canada. No review was done into aircraft imported into Canada from countries other than the United States concerning crashworthiness features.

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1 Chapter 523 of the Airworthiness Manual TP6197E.

5. CRASHWORTHINESS ACCIDENT INVESTIGATION AND ANALYSIS - UNITED STATES

5.1 Introduction

This section constitutes a review of major programs in the United States which have contributed to the R&D data base on accident analysis directly related to small aircraft crashworthiness. Accident analysis research has been addressed in two sections - Pre 1979 (5.2) and 1980-Present (5.3).

5.2 Accident Analyses Pre 1979[1]

One of the earliest formal general aviation crash survivability studies based upon aircraft accident investigations was reported in a 1943 Civil Aeronautics Board (CAB) publication (1). The CAB initiated this study "with the object of "finding injury facts and determining what number of crashes are survivable." The report concluded that: (i) "the force of many accidents now fatal is well within physiological limits of survival [and] needless injuries- both serious and fatal-are caused by the unfortunate placement and design of certain objects and structures ...," and (ii) "with a knowledge of injury causes, manufacturers and designers can modify or eliminate many hazards and provide conspicious degrees of emergency safety ..."

A 1944 Air Surgeon's Bulletin and a 1945 National Research Council study related the causes of injuries in light aircraft accidents (2, 3). In 1949, an analysis of injury to 1,942 occupants of 1,442 light airplanes was conducted to evaluate the types and locations of injuries (4). The incident pattern developed by these analyses was confirmed in a 1952 study of 800 survivors of light-airplane accidents which reported 704 injuries to the head, 641 to the lower limbs, 548 to the thorax, and 399 to the arms (5).

A study of light aircraft accidents during an eleven-year period ending in 1952 analyzed 913 accidents which involved 1,596 occupants and 15 aircraft models (6). This study found that in the accidents that resulted in 385 of the 389 fatalities, 143 occupants died in aircraft that remained intact or were not severely distorted. Another 155 occupants died in partly collapsed cabins which retained structural integrity. Of these 389 fatalities, 29[illegible] (77 percent) died in accidents in which the cabin structure appeared crashworthy, and the study concluded that "roughly 1/3 of the 389 people killed ... died unnecessarily.

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1 This section is extrapolated from NTSB SR-80-2, The Status of General Aviation Aircraft Crashworthiness, December 17, 1980.

In 1964, the CAB's Bureau of Safety[1] noted that from January 1964 through October 20, 1964, 826 fatalities resulted from general aviation accidents. Of these fatalities, the CAB estimated that about 200 could have been prevented if shoulder harnesses had been installed and used. This estimate was based on the CAB's study of 25 accidents selected at random. Based upon its findings, the CAB's Bureau of Safety made the following three recommendations to the Federal Aviation Agency (FAA)[2] for crashworthiness improvements:

> "Shoulder harnesses for each occupant be required on all newly certified general aviation aircraft unless it can be demonstrated that the seatbelt alone will preclude the seat occupant from contacting injurious objects within the striking radius of the head.
>
> Shoulder harnesses and crash helmets for each occupant be required on all aircraft engaged on a hazardous flight such as aerial spray applications [cropdusting] or [on a] "low and slow" flight such as game or wildlife count or aerial surveys.
>
> In line with the FAA's desire to promote aviation safety by education, ... issue a series of Advisory Bulletins to all pilots, stressing the desirability of utilizing safety equipment, such as shoulder harnesses and crash helmets, as a standard practice."

A 1970 Aviation Consumer Action Project report reviewed much of the history of aircraft accidents and research, regulations, and manufacturing factors involving crash survival, and included information obtained in personal interviews with aircraft manufacturers and FAA officials. This study concluded, in part, that:

1. Travel by light plane is the most lethal of the major forms of transportation.

2. The light plane industry is doing very little work in the field of crash safety to correct the situation.

3. The human body, restrained by seatbelt and shoulder harnesses, can tolerate, without injury, forces sufficient to collapse today's light planes.

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1 The CAB's Bureau of Safety was the forerunner of the National Transportation Safety Board.

2 Before 1966, when it was made a part of the U.S. Department of Transportation, the Federal Aviation Administration was the Federal Aviation Agency.

4. The arguments of the manufacturers against particular safety innovations on the grounds of economic infeasibility are undermined by the fact that the manufacturers have not, for the most part, taken the trouble to determine the marginal cost of added protection.

5. The light plane manufacturers have not approached crash injury protection with the normal engineering methodology which has been applied successfully to the performance aspects of the airplane.

6. The FAA sets standards which are minimum. These standards are not "the optimums, toward which the regulated should strive" [Quoted portion taken from FAA Order, "Rulemaking Policies for Safty and Air Traffic Rule," May 18, 1962].

7. It is unrealistic to expect that profit-oriented industry will strive toward optimums in an aspect of its product which has little direct effect on its profits, when only minimums are required.

Early general aviation aircraft accident investigation findings that the unrestrained or partially restrained (seatbelt only) occupant flails about within the cabin upon crash impact, striking various portions of the body against objects which penetrate or crush body structures, were confirmed in a 1953 National Advisory Committee for Aeronautics (NACA) study and in a 1971 FAA study (7, 8). The NACA study used anthropormorphic dummies in crash tests. Impact damage to the dummies and study of motion picture film on which the tests were recorded defined the injury mechanisms. The FAA study examined general aviation accidents to evaluate the extent to which design engineers had succeeded in applying the basic packaging principles identified by DeHaven in 1944 (3), and to identify reasons for the great disparity between automobile and general aviation aircraft accident statistics. The FAA study found that the fatality rate per 100 million passenger miles for automobiles was only 2.4 compared to 17.5 for general aviation aircraft. This sevenfold difference was accentuated further by the finding that only 1 fatality occurred for each 10 serious injuries in automobiles while 2 fatalities occurred for each 3 serious injuries in general aviation aircraft.

The FAA report concluded that:

> "... in most instances the well-known principles [DeHaven's packaging principles, (3) have been so grossly ignored that serious and fatal injuries have occured in anything more severe than a hard landing .... In fact, of all vehicles designed for human transportation, the so-called general aviation aircraft offer the least protection from, and chances of survival in, crash decelerations .... Minor or no injuries occurred in crashes of 1 and 2 "g"[1] decelerations. Severe but nonfatal injuries were common in 3 to 5 "g" accidents. Fatalities and very severe injuries occurred in crash decelerations of 6 to 10 "g". At

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[1] The term "g" represents the gravitational attraction at sea level upon objects (32.2 ft./sec. 2).

10 "g" and above, most present general aviation aircraft disintegrate to the extent that the value of restraint equipment for crash survival is doubtful.

While the FAA report was critical of the crashworthiness of most general aviation aircraft, it acknowledged that the Beech Aircraft Corporation (Beech) Bonanza "appears to have been about a 25 "g" cockpit and the Piper Aircraft Corporation (Piper) Pawnee one that can withstand impact forces up to 40 "g" ...." The report advocated that "the manufacturers of general aviation aircraft ... be encouraged to strengthen cockpit design of all future aircraft models." Also, the report stated that almost 100 percent of the occupants in the 70 aircraft accidents investigated were wearing seatbelts. The report concluded that passengers are aware of the need for restraint equipment and are willing to wear it in this type of transportation.

Other crashworthiness findings of the 1971 FAA study included:

1. In most cases, the seatbelts and seats themselves are inadequately attached to the cabin structure; thus, they fail or are ineffective even in moderate decelerations.

2. Even if seatbelts were ideally installed, only the pelvis would be restrained and an occupant's head, trunk, and appendages would be allowed to flail forward into structures which would be lethal even in minor-velocity body impacts.

3. The area forward of the front seat occupants is extremely unsafe for body impact because of lethal protrusions, lack of slow-return padding, sharp edges, etc.

4. The use of properly designed and installed shoulder harnesses would help prevent impact of the head and upper torso.

A researcher's analysis of general aviation accidents during the 10-year period ending in 1976 (9) reported that some 97,211 individuals were involved in 46,576 accidents, which resulted in an average of 1,364 fatal injuries and 696 serious injuries annually. When the historical incidence, patterns, and severity of general aviation crash injuries were compared to automobile crash injuries, over the 10-year period ending 1977, the report concluded that while no incidence of injury changes were yet evident in the majority of general aviation aircraft accidents, improvements could be seen in the automobile statistics. This finding was attributed to the occupant protection improvements required by the Federal government. The report concluded that FAA design requirements were "considerably behind the state-of-the-art," and that the majority of general aviation manufacturers had not taken strong initiatives in the past to provide occupant upper torso restraint. The report further stated that:

> It has been found that [the accident can be survivable] when cabin structures remain essentially intact without intrusion, the occupant is adequately restrained, interior-contact structures are designed to distribute load and provide energy absorption, the seating system provides adequate support and energy absorption, and the impact forces upon the occupants are within human tolerance values ....

Crashworthiness deficiencies found in general aviation aircraft in that accident analysis (9) included:

1. Lack of adequate upper torso restraint. Head injuries remain the most frequent injury as well as the major cause of death and serious trauma. This usually occurs when the occupant jackknifes over the seatbelt and contacts hard, sharp, unyielding, rigid structures.

2. Inability of seats to adequately attenuate vertical compressive forces. The report acknowledges that recent attention has been given to improved design of the front seats, but the rear seats do not appear to provide equivalent protection.

3. Seat support and attachment failures which can subject occupants to unfavorable positions that greatly reduce tolerance to injury.

4. Cabin interiors that contain many lethal surfaces, structures, and objects which cause death or serious trauma upon crash impact. Flailing appendages, even when upper torso restraints are worn, can contact rudders, controls, sharp edges of the control yoke, and nonyielding structures.

Safety Board investigations of 14 general aviation accidents during 1979 (10) correlate well with the above accident analysis findings. In each accident, the aircraft cabin maintained enough structural integrity for occupants to survive. However, either because shoulder harnesses were not available or were not worn when available, because seat structures failed, or because cabin interiors were not "delethalized," needless fatalities and serious injuries resulted.

5.3 Accident Analyses 1980-Present

General aviation aircraft accident analyses took a giant step forward after 1979. In an effort to gather data to further support previous NTSB recommendations for improved general aviation crashworthiness, the NTSB conducted a general aviation crashworthiness study from 1981 to 1985. Three reports were published that 1) validated crashworthiness investigative techniques; 2) defined the impact severity and potential injury prevention for survivable accidents; and 3) defined acceleration loads and velocity changes of survivable accidents. The Safety Board was also able to define the extent that post-crash fires affect survivability.

Throughout this program two approaches were taken to compile data. One approach was for a team of trained crashworthiness investigators to complete detailed on-scene investigations of selected survivable accidents to document the structural deformation of the airplanes, the impact severity of the crash, and the resultant injuries to the occupants. Acceleration loads were then calculated for each accident. The methodology for these analyses was developed and described in the NTSB Report "General Aviation Crashworthiness Project Phase One". Analyses of these selected accidents were later presented as part of a Phase Three report.

The other approach was to compile, beginning in 1982, more detailed kinematic and injury information for all general aviation accidents. For this project the NTSB developed a more comprehensive accident investigation form allow for detailed on kinematic and injury information. A copy of this form is located in Appendix 1. This was the information which was used for the basis of the Phase Two Report.

The overall objective of the crashworthiness program was to develop and disseminate to the FAA and the general aviation industry an envelope of likely peak declerative forces occuring in survivable[1] general aviation airplane accidents, and their effects on the occupants and airplane structure for the purpose of upgrading occupant protection design standards. The program was intended to describe and categorize by severity, crash scenarios for a range to survivable airplane accidents. Also, the program was to correlate the scenario categories with the savings in lives and the reduction in serious injuries which might be achieved by upgrading the design standards of general aviation airplanes to levels compatible with these scenario categories.

The results of the program were published in a three-volume report comprised of:

Phase One - Crashworthiness Analysis Methodology

Phase Two - Impact Severity and Potential Injury Prevention in General Aviation Accidents

Phase Three - Acceleration Loads and Velocity Changes of Survivable General Aviation Accidents

Since the information and the background findings supporting these three volumes represent the key work in the general aviation accident analysis field since 1980, an overview of the contents excerpted from each Phase is presented in the pages that follow.

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1 A survivable accident is one in which the forces transmitted to the occupant through the seat and restraint system do not exceed the limits of human tolerance to abrupt accelerations and in which the structure in the occupant's immediate environment remains substantially intact to the extent that a livable volume is provided throughout the crash sequence.

5.3.1 Phase One - Crashworthiness Analysis Methodology

The initial report explains the crashworthiness program, its objective, and its goals. It presents a description of the crashworthiness methodology used, demonstrates its validity, and provides an example demonstrating its application. The scope of this report is limited to the presentation of the investigative and analytical methodology, and does not include any detailed analyses of the data obtained from the Board's accident investigations.

Goals

The goals of the program were as follows:

- Establish investigative techniques which will facilitate the collection and analysis of crashworthiness data for general aviation accidents.
- Collect and evaluate, through detailed analysis, crashworthiness data on a select sample of survivable general aviation accidents.
- Validate analysis techniques which can be applied to the future analysis of the substantial amount of crashworthiness data which will be collected routinely in general aviation accident investigations.
- Define crash pulses that describe the impact severity of survivable accidents in general aviation airplanes currently in use.
- Identify injury-producing mechanisms related not only to the fuselage structure, but to control/display designs, crew/passenger seats, and possible deficiencies in the availability and use of seat belts/shoulder harnesses, and correlate these with the crash loads.
- Describe and categorize crash scenario severity based on changes in velocity and impact angle.

Data Requirements

The data requirements identified to support the achievement of the objective were in three major areas:

- occupant injuries
- impact severity
- airplane's occupant protection capabilities

Occupant Injuries

Occupant injuries of concern in the crashworthiness study were those resulting from either accelerative or mechanical sources. It is known that abrupt acceleration (+ or -) of the body or parts of the body can result in injuries, such as hyperextension of the cervical spine (whiplash) from

acceleration[1] in the vertical direction. Mechanical injuries, also referred to as blunt trauma or impact injuries result from the body's striking or being struck by another object. A typical mechanical injury is a fractured skull or facial laceration which results from head contact with the instrument panel, seat back, or window jamb during a crash sequence.

The detailed data concerning occupant injuries were to be collected from autopsy records, hospital records, and interviews with victims and medical/rescue personnel who responded to the accident.

Identification of the injury mechanisms or the direct causes of the injuries, an important part of the investigation process, was to provide information on the occupant protection capabilities of the airplane. Although injuries caused by accelerative forces may be identified as such, the magnitude of the forces causing the injuries must be identified through kinematic[2] analysis of the airplane crash. Impact injuries, in general, can be traced by physical evidence to occupant contact with particular structures in the cockpit or cabin of the airplane.

Airplane Impact Severity

The severity of a crash is stated in terms of a crash pulse which relates acceleration ("G")[3] acting at the airplane's center of mass to time. The pulse is determined by the analysis of the airplane's kinematics which is established through the reconstruction of the crash sequence. The kinematic analysis requires knowledge of the velocity change of the airplane, the distance over which the velocity change took place during the principal impact[4], the airspeed, the flightpath angle, the terrain angle, the airplane's attitude at the principal impact, and the sliding distance after the impact. These values are determined from physical evidence, including damage to the airplane structure, damage to objects in the crash path, and ground scars. Additional data that are useful in establishing the required parameters can be obtained from radar data, aerodynamic analyses, and flight data recorders when they are available.

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1 Acceleration is the change in velocity with respect to time. In general, the term "acceleration" refers to an increase in velocity with respect to time, and is expressed as a positive (+) number. A decrease in velocity with respect to time is a negative (-) acceleration, or a deceleration.

2 Kinematics is a branch of dynamics that deals with aspects of motion apart from consideration of mass and force.

3 Acceleration in G's is the ratio of a particular acceleration to the acceleration of gravity.

4 Principal impact occurs when the major decelerative forces are experienced and the most damage is sustained by the fuselage. The principal impact may not necessarily be the initial impact.

Occupant Protection Capabilities

The determination of how well an airplane can protect its occupants in a crash depends on more than documentation of injuries and analysis of the airplane's kinematics. Information is required on how much energy of the crash was absorbed by the structure and components through plastic or permanent deformation. Also, information is needed on whether or not the occupants were restrained sufficiently to allow them to have participated in the airplane structure's deceleration, or whether or not they experienced an abrupt, and perhaps nonsurvivable deceleration, because the tiedown chain[1] failed to restrain them. Such information is gathered during a detailed examination of the airplane wreckage. Also, fuselage deformation must be measured to determine whether a livable volume is maintained in the occupied area. Impact damage must be documented, and matched to the environmental evidence, i.e., ground scars, tree strikes, and other collisions with obstacles, and evidence must be collected on seats and on the availability and use of restraints, and failures or deformation of these components and the components comprising the rest of the tie-down chain.

Analysis Method

Impact severity was determined through a kinematic analysis.[2] Data for this analysis was collected at the crash scene using standard investigative techniques. The beginning and end of the principal impact are defined, and the peak decelerative force is derived from the estimated velocity change and the distance travelled by the airplane's centre of mass during impact. The analysis provided a set of peak decelerative force values which bracketed the unique or actual peak force for that crash by determining the minimum possible peak decelerative force and the peak decelerative force for a triangular shaped pulse. This analysis methodology worked well when applied to crash tests of general aviation airplanes that were performed by NASA.

To establish an envelope of representative crash forces from the bracketed solutions, it is necessary to use all known facts from field and test data to narrow the bracket for each crash pulse to approach its precise solution. However, the data available from the crash scene may be so limited that the kinematic reconstruction can be performed only for one direction, i.e., the physical evidence may be sufficient to allow an analysis of the vertical crash loads but may be insufficient to allow an analysis of horizontal crash loads. Also, even if in one accident all data could be measured precisely and loads calculated exactly, that accident would not necessarily be representative of all survivable general aviation accidents. Therefore, a substantial number of crash analyses is required to establish the pulse(s) that are representative of current general aviation airplanes.

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1 The seat, restraints, seat tracks, bulkhead/floor, subfloor structure, and attachment hardware which act as a system to restrain and to protect the occupant.

2 Kinematics is a branch of dynamics that deals with aspects of motion apart from consideration of mass and force.

Certain data needed to establish the crash pulses by kinematic analysis are obtained from two procedures. The first procedure is the visualization of the crash sequence, the results of which provide impact attitude and crushing distance. The second procedure is the development of a crash pulse that, when integrated, will generate the documented velocity change and stopping distance.

Visualization

Orthographic Drawing - The most effective method of visualizing the impact attitude, flightpath angle, and the amount of crush that occurs is to create an orthographic drawing incorporating the impact data gathered in the field. Damage to the airframe, ground scars, and tree strikes can be documented through the use of measurements, photographs, sketches, and drawings and notes made on airplane three-view drawings. When all available impact information is documented, reconstruction of the airplane's impact attitude is possible, and more confidence can be placed in the attitude reconstruction when several ground scars are present. The technique requires that the ground scars be aligned with the airplane components which caused them. Typically, distinctive gouge marks are left by components, such as landing gears, propellers, engine nacelles, and wing tips. Changes in the airplane's attitude may result from these components striking the ground during the crash sequence.

Crush Line - Another technique for establishing the impact attitude of the airplane is through the use of crush line. The crush line is formed as a result of the airframe being crushed against a surface and leaving a distinctive flat or "stamped" area on the airframe. In general, the crush line can be identified by small, tight wrinkles in the skin, or by deformation of the airframe surfaces around longerons or stringers. This type of damage is caused by direct contact between the airplane and the ground. Points representing the edges of the damaged areas are plotted on an airplane three-view drawing and straight lines are drawn between these points Figure 5-1). Several lines intersect to create an imaginary plane or flat surface, i.e., crush line. The impact attitude can be determined graphically by relating the crush line to the impact surface. The rotation required to place the crush line on the impact surface defines the airplane's pitch, roll, and yaw attitudes at impact relative to that surface. Correcting for surface slope will yield these attitudes relative to the horizon (Figure 5-2).

The pitch attitude of the airplane at impact can be calculated by algebraically adding the values for the flightpath angle and the angle of attack. The flightpath angle is determined by aligning sequentially tree or object strikes and the ground impact point. The angle of attach can be estimated based on the airplane's speed and maneuvers just before impact. Although not as precise as using several ground scars, the value for pitch attitude derived by this method is sufficiently accurate for purposes of analysis when no other information is available.

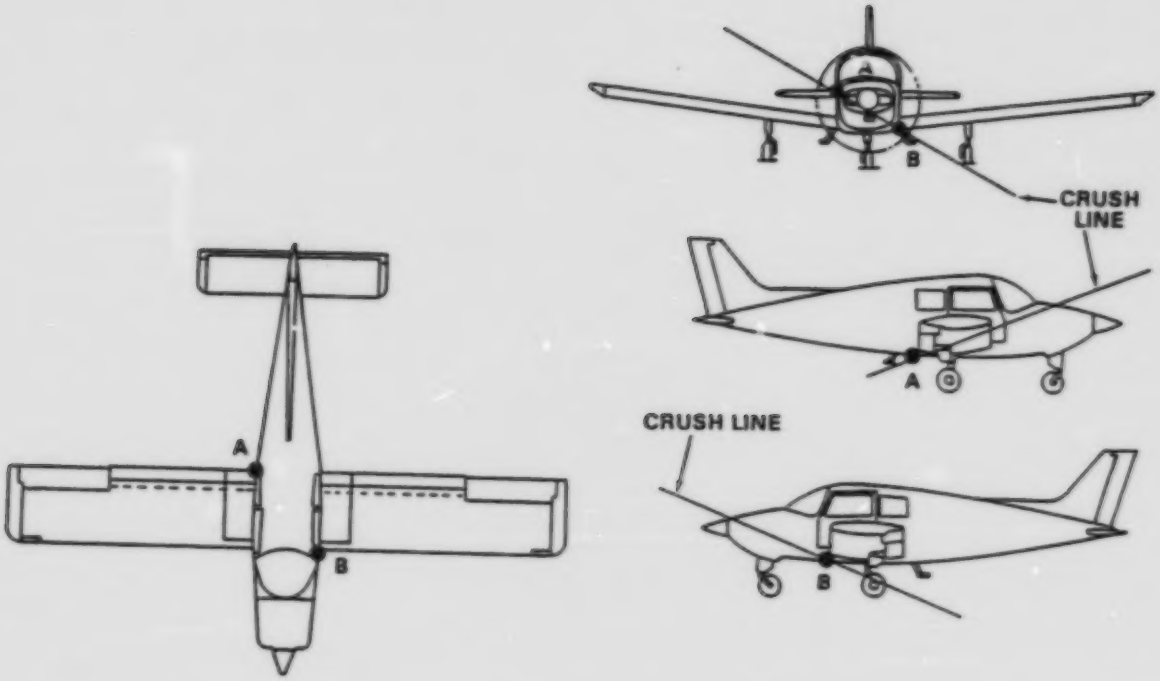

Figure 5-1. Crush Line Documentation

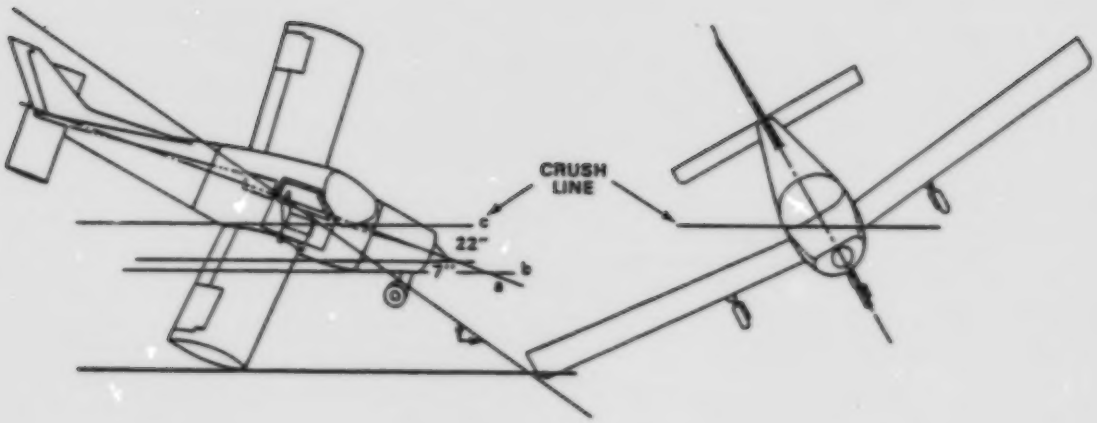

Figure 5-2. Crush Line and Distance Marks

Change In Velocity - Once the stopping distance has been established, the change in velocity during the principal impact must be determined. The initial velocity is estimated based on knowledge of the airplane's maneuvers just before impact, the airplane's performance parameters, the pilot's statement, or a witness statement. For example, an airplane may have been seen flying level in a nose high attitude and pitching over just before hitting the ground. From this information, it can be assumed that the airplane was at or near stall speed when the impact occurred. Another examples is a twin-engine airplane that crashes out of control after power is lost in one engine. In this case, it is reasonable to estimate that the initial velocity was near the airplane's single engine minimum control speed (V_{mca}). Witness statements, radar data, and airspeed readouts from flight data recorders, if available, also are helpful is estimating the initial velocity.

The total velocity component at the principal impact acts along the flightpath. The flightpath angle is used to break down the total velocity component into the vertical and horizontal components, relative to the horizon (Figure 5-3). In the vertical direction, the final velocity is used to determine the velocity change. The final velocity usually is zero because the maximum vertical crush is achieved when the downward movement is stopped by the ground during the principal impact.

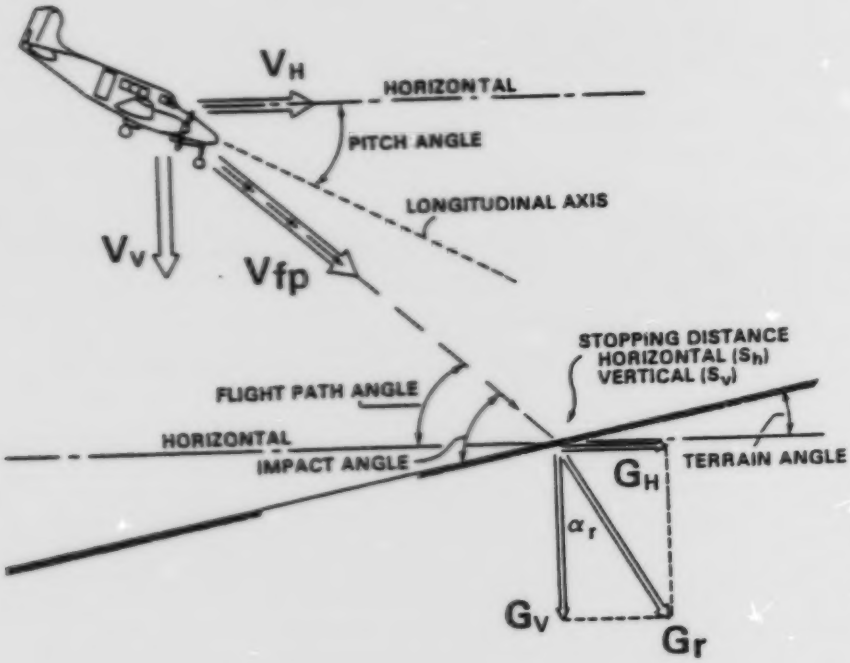

Figure 5-3. Vector Components

As vertical velocity becomes zero, the maximum vertical crush is achieved. In the horizontal, direction, most airplanes tend to slide along the ground for some distance after the principal impact, and the difference between the initial velocity and the final velocity (a value greater than zero) must be established for the principal impact.

In crashworthiness analysis, the velocity change is the most critical item and is the most difficult parameter to estimate. In the formulae for the calculation of the G-loads, the velocity appears as a squared factor, thus magnifying small errors in the estimate. Last second maneuves of the airplane (controlled or uncontrolled) also can change the velocity by a small but important amount. Accounting for these changes is a difficult task and care must be taken to utilize all available information.

After establishing values for distance and velocity changes during the principal impact, the final step is to estimate the horizontal and vertical crash pulses, or a combined pulse, which represents the change in velocity over the measured stopping distance.

Method Verification

Verification of the accuracy of the techniques used to determine the crash pulse was accomplished through the analysis of four NASA tests, using NASA's published data (12). This effort included comparison of Safety Board analyses based on physical evidence from NASA crash tests of general aviation airplanes with the actual parameters and results from those tests. Crash loads based on rectangular and triangular shaped crash pulses were calculated for each crash test.

Pitch Attitude - Several crash tested airframes, which were stored at the NASA Langley Research Center, were inspected and documented by Safety Board investigators, using the Board's normal accident investigation procedures. The goal of the exercise was to establish the airplane's impact attitude based only on the crush line and othe fuselage deformation. Once the damage was documented and an impact attitude was established, a comparison was made with the NASA data, i.e., actual decelerations measured by instrumentation during the crash tests.

The measurements taken from the crush lines of the test airplanes were found to approximate closely the airplane's attitudes at full development of the crushing. The comparison measurements were taken from NASA's crash test films. The film analyses showed that, when crashed on concrete, the airplanes tended to rotate or bend during the principal impact, causing a change in pitch attitude between 3° and 9°. An example of this pitch rotation was identified in the film of a 45° nose down drop test. The airplane initially contacted the ground at 45°, but at the fully crushed position, the fuselage had rotated to a pitch angle of 36°. In the analyses of other drop test films, it was found that several of the 30° nose down tests resulted in pitch attitudes of 26°, and for 15° nose down tests, the pitch attitudes at full crush development were 12°.

Other techniques for estimating pitch attitude also were verified. One technique was the use of distinct bend lines found in the floor boards of the test vehicles. Parallel wrinkles in the fuselage skin were reasonable indicators of pitch attitude at full development of the crush. In general, the parallel wrinkles were found to be valid indicators if they did not emanate from an area of major structure.

Each of the techniques described is a useful tool for estimating pitch attitude at impact. However, an investigator must exercise sound judgment in basing conclusions on this evidence because each piece, taken by itself, can be misleading. Conclusions with the highest level of confidence result from the use of a number of techniques to confirm an impact attitude.

Crash Pulse - A visualization of each test was made to establish the target values for distance. The NASA values for velocity and flightpath angle were used in calculating the crash pulse. The impact data could not be generated for the NASA tests as they would be in an NTSB field investigation. Velocity, impact attitude, angle of attack, and flightpath were artificially set for test purposes for the NASA tests and their values could not be estimated by using techniques that would be applied in the field.

Crash pulses first were calculated relative to earth axes, then converted to airplane axes to allow comparison with accelerometer data from the NASA tests. Initial evaluations indicated that when the airplane crashed on an unyielding surface, such as concrete, the predominant (reaction) occurred in the vertical direction relative to the earth. However, when the crash occurred on a yielding surface, such as dirt, the loads were predominantly longitudinal, relative to the airplane axis as it dug into the ground. Stated in another manner, in both cases, the reaction to the force of the impact was normal, or at right angles to the impact surface. This reaction follows Newton's third law of motion which states that, for every action, there is an equal and opposite reaction.

If the airplane crashes on a yielding surface but does not dig in and stop, the physical evidence must be carefully evaluated to determine in which axis the predominant loading occurs (Figure 5-4).

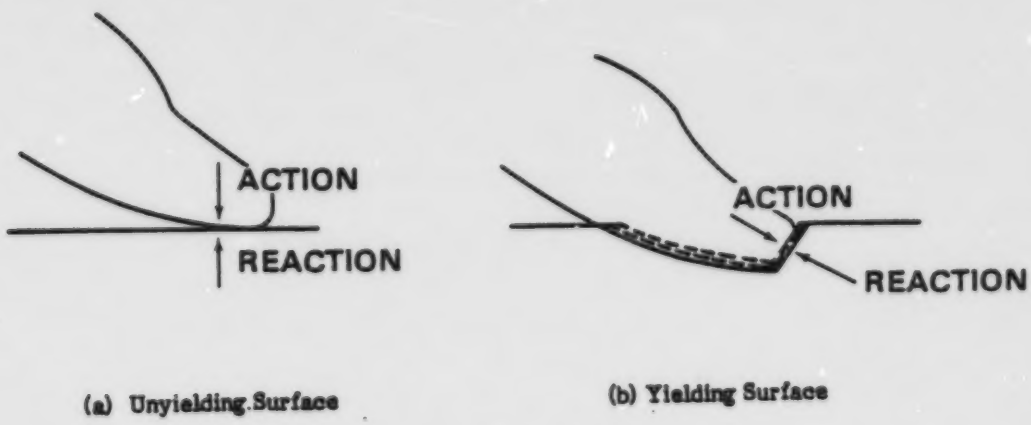

Figure 5-4. Direction of Reactions

Identification of the predominant axis is important because analysis of the crash loads along this axis is more accurate and more easily accomplished rather than attempting the analysis in a nonpredominant axis, and then translating the results to the predominant axis.

Some disagreement will arise in the comparison of the published test data with the calculated crash pulse data during verification because the time histories of the vertical and horizontal pulses cannot be compared. If the vertical and horizontal crash pulse peaks do not occur at the same time, the vector analysis, using the vector sums, is not entirely accurate. However, the calculations for the predominant pulse and the total vector sum will be reasonably accurate.

Results of Safety Board documentation and analysis of two NASA general aviation crash tests using the methodology presented, compared well with NASA's published test data. This indicates that the methodology and assumptions developed for use in this program are valid.

5.3.2 Phase Two - Impact Severity And Potential Injury Prevention In General Aviation Accidents

Methodology

To define the impact severity of survivable accidents and to estimate the benefits to be derived from the availability and use of shoulder harnesses and energy-absorbing seats, the Safety Board used data available in the investigative reports of 535 selected accidents that occurred in 1982 to perform a detailed analysis of crash kinematics and occupant injuries. Accidents selected as suitable for this examination were general aviation airplane accidents in which at least one occupant was fatally or seriously injured. Certain airplanes such as aerial application airplanes, homebuilt airplanes, and older airplanes of fabric and tube construction were excluded. The selected accidents also limited to airplanes which are expected to continue to be in production and hence would be the most likely candidates for improved crashworthy designs.

Data available concerning each of these accidents were evaluated by investigators experienced in the analysis of patterns of injury causation in general aviation airplane accidents. A detailed analysis was made by examining completed investigative forms, narratives, photographs, witness statements, and medical information in order to estimate the extent to which each accident was survivable and to compile information on impact speeds and impact angles. For the purpose of this study, an accident was considered to be survivable when a livable cabin volumes was maintained throughout the crash sequence and the forces transmitted to the occupant through the seat and restraint system did not appear to have or should not have exceeded the limits of human tolerance to abrupt accelerations. Therefore, an accident was considered to be survivable when at least one occupant either survived or could have survived if shoulder harnesses or energy-absorbing seats had been used.

A partially survivable accident is a survivable accident in which at least one fatality occurred that could not have been prevented. Potential survivors were identified in each accident by examining accident data describing the damage to the airplane and the injuries of each occupant. First, the "livable volume" was evaluated for each seat. Photographic documentation was the primary source of this information. To be considered livable, each space where an occupant was seated had to have remained large enough for survival throughout the crash sequence. Individual locations considered nonsurvivable were those where the livable volume had been reduced drastically or has been destroyed. An example of a nonsurvivable accident is one in which the volume had been reduced during the crash by a crushing structure that had rebounded, thus giving a final appearance of a livable volume. Secondly, the injuries of each of the occupants were evaluated separately, taking into account the availibility and use of occupant restraints and the retention of seat structures in their normal positions, post-crash fires, and other important factors. An assessment was made, wherever possible, of the degree to which injuries could have been lessened by the use of shoulder harnesses or energy-absorbing seats.

Analysis

The study group for this report is comprised of 535 accidents involving 1,268 occupants, of which 391 accidents resulted in at least one fatality. In these 391 accidents, there were 859 fatalities, 74 occupants who survived with serious injuries, and 19 occupants who survived with minor or no injuries. All occupants were fatally injured in 85 percent of the 391 fatal crashes. In 144 accidents in which no one was fatally injured, 228 occupants were seriously injured and 87 occupants received minor injuries. One occupant's injuries could not be determined.

The analysis for this study group is presented in two sections: first, impact severity is discussed in terms of impact angles and impact speeds, and the impact severity envelope (referred to in this report as the survivable envelope) is determined for survivable accidents. Second, the potential for injury prevention, made possible by shoulder harnesses and energy-absorbing seats, is presented.

Impact Severity - Impact severity was defined in terms of impact angle and impact speed, the most readily available parameters that can be related to the survivability of an accident. Each accident was determined to be survivable or nonsurvivable, and, for most of the accidents, impact speeds and impact angles were estimated. After the impact severity estimates were made, each accident and occupant were represented on the polar plots.

The impact severity increases with impact angle because the velocity change during the principal impact becomes greater at increasingly higher impact angles. At shallow impact angles, the airplane "hits and skips" with relatively small velocity changes. At high impact angles, the airplane "hits and sticks". Which results in a greater velocity change or a more severe impact.

The distributions of impact speeds and impact angles for survivable accidents versus nonsurvivable accidents were compared (Figures 5-5 and 5-6). There were a significant number of survivable accidents at impact speeds of less than 90 knots and at impact angles of less than 45 degrees. There were very few survivable accidents outside this range. In contrast, there were proportionally fewer nonsurvivable accidents at impact speeds of less than 90 knots and at impact angles of less than 45 degrees.

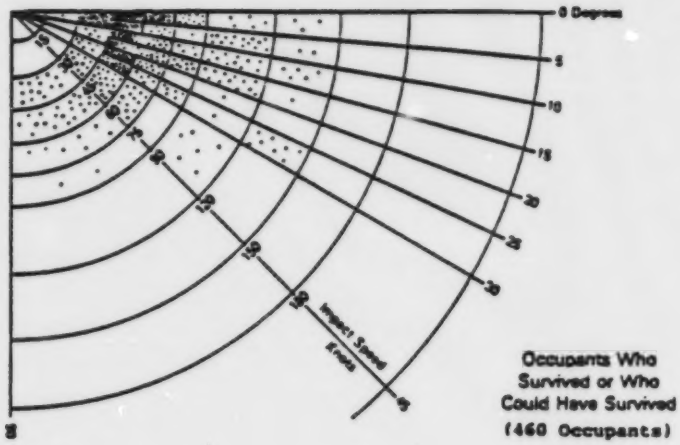

Figure 5-5. Impact Angles and Speeds

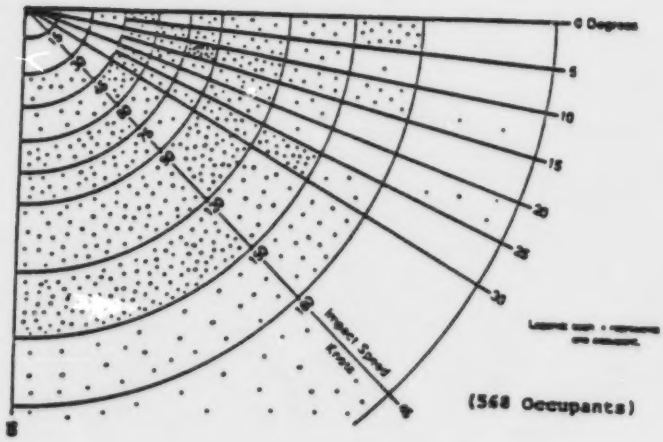

Figure 5-6. Occupants In Nonsurvivable Accidents

Figures 5-5 and 5-6 were compared to establish whether the difference between survivable accidents and nonsurvivable accidents was one of impact severity. Any difference which could be demonstrated would define the limits of the survivable envelope. First, the density plots of Figure 5-5 and Figure 5-6 were overlayed. In another comparison, the plots were redrawn as rectangular plots so that dot density of various sectors could be directly compared. These rectangular plots also were overlayed for comparison.

Comparisons of the dot density of a sector in the low-speed range to the dot density of a sector in the high-speed range can be misleading. For example, in Figure 5-5 between the lines forming the angles of 30 and 45 degrees, the sector between 75 and 90 knots is twice as large as the sector between 30 and 45 knots, even though both represent equal changes in velocity and angle. As a result, the relative dot density for differing impact angles within a given speed range are valid, however, as are comparisons amond individual sectors from figure to figure.

These comparisons produced a boundary, or visible difference, between the two groups. The difference was most clear as a line which extends from 0 degrees at 75 to 90 knots, to 45 degrees at 60 knots, and to 90 degrees at 60 knots. A special effort was made to evaluate nonsurvivable accidents which fell inside this limit and to evaluate survivable accidents which were outside this limit.

Most of the latter accidents differed from the other survivable or nonsurvivable accidents within their respective severity ranges in some of the following ways. In the lower speed, survivable region, nonsurvivable accidents included those involving inverted crashes or direct tree or other object strikes to single occupants. In the high-speed and/or low-angle impact region, a survivable accident would include an airplane cruising into gently rising terrain and sliding over some distance to a stop without generating significant loads.

As plotted, an impact angle of 90 degrees appears to be the limit of the survivable envelope for a 60 knot impact. However, examination of the accident reports shows that the survivable impacts plotted in the 45- to 90-degree sector actually are distributed much more closely to the 45- degree line than is shown by the even distribution of the plot. Since the data in that sector are biased more toward the 45- degree line, the survivable impact speed limit at an impact angle of 90 degrees is more nearly 45 knots.

Similarly, many accidents in the impact speed range of 75 to 90 knots were only marginally survivable. The survivable occupant density depicted in Figure 5-6 in the 75- to 90- knot sectors probably is actually aligned more closely withthe 75 knot limit.

The resulting boundary of the survivable envelope is depicted in Figure 5-7 by a line from zero degrees at 75 knots, to 45 degrees at 60 knots, and to 90 degrees at 45 knots.

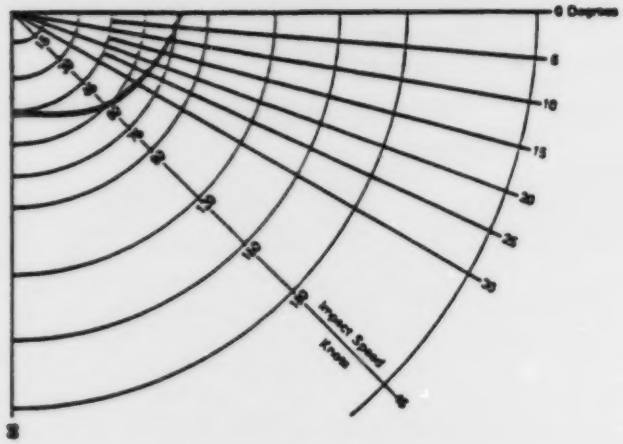

Figure 5-7. Survivable Envelope

Potential Benefits Of Shoulder Harnesses And Energy-Absorbing Seats - In addition to developing data on impact severity, an important part of this Phase Two study was to assess the magnitude of the benefits that could be expected from the use of shoulder harnesses and energy-absorbing seats.

There were five survivable accidents in which shoulder harnesses were worn by only one of two front-seat occupants. A comparison was made to the relative injuries of each occupant. It was found in each case that injury severity was less for the occupant who wore the shoulder harness. The impact angles ranged from near zero degrees to 30 degrees, and impact speeds ranged from 30 to 75 knots. As expected, the higher speeds corresponded to impact angles under 15 degrees, and the higher impact angles (greater than 20 degrees) corresponded to the lower impact speeds. None of the accidents involved post-crash fire Table 5-1).

Table 5-1. Side-By-Side Injury Comparison

Example	With Shoulder Harness	Without Shoulder Harness	Impact Speed (knots)	Impact Angle (Degrees)
1	Serious	Serious	45-60	5-10
2	Minor	Serious	60-75	0-5
3	Minor	Serious	45-60	0-5
4	Minor	Serious	30-45	25-30
5	Serious	Fatal	45-60	0-5

In each of these accidents, the occupant who wore a shoulder harness had fewer and less severe injuries than the occupant who did not. For example, in one accident each of two occupants sustained serious injuries, but the pilot, wearing shoulder harness, sustained a broken leg and a slight concussion while the passenger without a shoulder harness sustained severe head injuries. The differences in the injuries in these comparisons were related to head and upper body injuries. Those persons who wore shoulder harnesses had markedly fewer head injuries. As would be expected, shoulder harnesses did not prevent injuries to the lower torso or to the extremities.

Estimates Of Shoulder Harness Benefits - Since this study did not evaluate accidents in which the injury levels were only minor and none, the estimates of shoulder harness benefits presented in this report are conservative. For example, there were a number of severe accidents in the 1982 data base in which occupants received only minor or no injuries, because they were wearing shoulder harnesses. While an analysis of these accidents would have further strengthened this study, there was no timely way to isolate those accidents. Further, the estimates of benefit presented in this report are based on the existing fleet of general aviation airplanes. Any improvements in airframes which are incorporated in the future that will result in improved preservation of the "livable volume" will increase the importance of shoulder harness use.

There are two important elements which must be satisfied in order to realize the full benefits of shoulder harnesses. First, the shoulder harness must be available for use. Only 40 percent of all airplane occupants examined in this study had shoulder harnesses available. The second element is that of use; a shoulder harness cannot protect an occupant from injury in a crash if it is not being worn. Of the 253 occupants whose shoulder harness use could be determined, only 100 persons, or 40 percent, actually used the available devices (Figure 5-8). Combining the availability rate (40 percent) and the usage rate (40 percent) indicates that 16 percent of the occupants were wearing shoulder harneses.

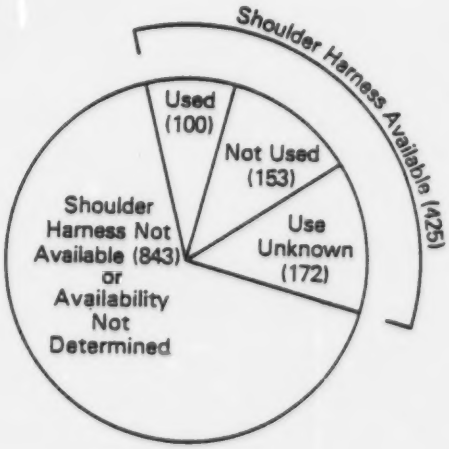

Figure 5-8. Shoulder Harness Availability and Use

Of the occupants examined in this study, 71 percent occupied front seats, and 97 percent of the persons wearing shoulder harnesses were front-seat occupants. This indicates that the use of a shoulder harness is confined almost entirely to front seats. Shoulder harness availability was determined for 771 of the 902 front-seat occupants. Fifty percent of those occupants (382 out of 771) had shoulder harnesses available. Shoulder harness use could be established for 240 of the 382 front-seat occupants. Forty percent of these occupants (97 out of 240) wore their shoulder harnesses.

Fewer shoulder harnesses were available for rear seat occupants. Availability was determined for 304 of the 366 rear occupants. Fourteen percent of those occupants (43 out of 304) had shoulder harness available. Shoulder harness use could be established for 13 of the 43 rear seat occupants. Only 23 percent of these occupants (3 out of 13) wore their shoulder harnesses.

Many of the occupants who had shoulder harnesses available were not required to wear them. Although crewmembers are required to wear shoulder harnesses for takeoffs and landings, many did not. Some crewmembers forgot to put their shoulder harnesses back on when it became evident that an in-flight emergency would lead to a crash. These issues will be addressed in the Phase Three report.

Each of the 1,268 occupants was evaluated separately. Potential benefits were established for 1,111 occupants. The potential benefit for the 157 remaining occupants could not be determined. Detailed data were collected on specific injuries and on the extent to which these injuries either could have been prevented or could have been less serious through the use of a shoulder harness. Of the 859 fatally injured occupants in this study, the potential for benefit of shoulder harnesses could be established for 800 persons. There were 163 occupants who could have survived but did not. It is estimated that at least 13 percent (106) of the 800 fatally injured persons in these accidents would have been injured only seriously if they had been using shoulder harnesses and that an additional 7 percent (57) of the fatally injured persons would have had only minor or no injuries. The expected benefits are even more pronounced for those who were seriously injured. Fully 88 percent (201) of the 229 seriously injured persons who could be evaluated in this study probably would have received less severe head or upper body injuries, only minor injuries, or no injuries at all if shoulder harnesses had been worn (Figure 5-9 and Table 5-2).

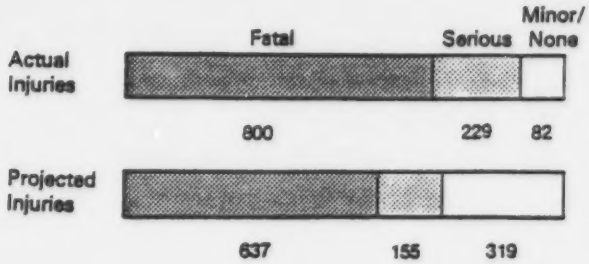

Figure 5-9. Distribution Of Occupant Injuries as Actually Occurring and as Expected With Full Shoulder Harnness Use.

Table 5-2. Injury Distribution As Actually Occuring and As Predicted Given Full Shoulder Harness Use

Occupant Injury Level	Original Injury Distribution	Predicted Injuries With Shoulder Harnesses	Percentage Change
Fatal	800	637	-20
Serious	229	155	-32 (-41)
Minor/None	82	319	N/A
	1,111	1,111	

The 163 fatally injured occupants who would not have been injured fatally if a shoulder harness had been worn would have received, instead, serious, minor, or no injuries. Likewise, 180 of the persons (79 percent) who were injured seriously without shoulder harnesses would have had only minor or no injuries with a shoulder harness. As a result, the net change is a 20 percent reduction in fatalities and a 32 percent reduction of serious injuries. In addition to this benefit, 21 persons (9 percent) of the seriously injured occupants in this study, while still expected to have serious injuries even with a shoulder harness, would have had significantly less serious head or chest injuries.

The percentage change in benefits of shoulder harness use is not as graphic as would be the case if only survivable accidents are considered. In total, 584 of the fatally injured occupants were removed from the data base because they were involved in nonsurvivable accidents. Thus, in survivable accidents only, shoulder harnesses could have prevented 75 percent (163) of the 216 fatalities, and 79 percent of the 229 serious injuries. Overall, of all occupants of survivable accidents who had fatal or serious injuries, 82 percent could be expected to have received a significant benefit in terms of injury reduction through shoulder harness use (Table 5-3).

Table 5-3. Occupants In Survivable Accidents: Potential Benefits Of Shoulder Harness Use

Original Injury Distribution		Expected Distribution With Shoulder Harnesses		Percentage
Fatal	216	Fatal	53	25
		Serious	106	49
		Minor/None	57	26
Serious	229	Serious	49 (21)	21
		Minor/None	180	79
Total Of Fatal and Serious	445	Total Who Benefitted	343 (364)	77 (82)

Estimate of Energy-Absorbing Seats Benefits - Energy-absorbing seats cannot be expected to prevent many fatalities since the predominant injuries which they can prevent are spinal injuries. These injuries rarely result in a fatality except when they prevent timely egress. However, they usually are severe, long-lasting, and costly. Evaluation of the data in this study indicated that about 2 percent of the fatalities could have been prevented if energy-absorbing seats had been available. Many serious back and neck injuries can be prevented if vertical energy management is considered during seat design. This study found that about 34 percent of the occupants who had serious injuries could be expected to have had significantly fewer serious injuries if they had been seated in energy-absorbing seats.

An important consideration in achieving these potential benefits is that, in order for an energy-absorbing seat to provide occupant protection, the occupant must remain in an upright position and the seat must remain in place. This means that the occupant must be restrained by a lapbelt and shoulder harness. Installation of improved seats, in the absence of shoulder harness use, will not produce the improvement noted above. Moreover, it is important to note that nearly 27 percent of the seats in survivable accidents did not remain attached. When a seat does not remain securely attached to the floor, occupant injury protection offered either by the seat or by the lapbelt and shoulder harness is considerably reduced.

To summarize the benefits that could be expected from the use of shoulder harnesses and energy-absorbing seats, it was established that 20 percent of all fatalities could have been prevent by the use of shoulder harnesses and that 91 percent of the seriously injured occupants could have had less serious head, upper body, and/or back injuries with the use of shoulder harnesses and energy-absorbing seats combined. Shoulder harnesses alone could have prevented or minimized the severity of the head and upper body injuries for 88 percent of the seriously injured occupants; energy-absorbing seats could have prevented or minimized the severity of back injuries for 34 percent of the seriously injured occupants.

Conclusions - Phase Two

(a) Shoulder harness use is the most effective method of reducing fatal and serious injuries in general aviation airplane accidents.

(b) New crashworthy airframe design is the improvement which will most significantly expand the survivable envelope to higher impact speeds.

(c) Impact severity, as defined by impact speed and impact angle, is a principal determinant of a survivable accident.

(d) The accidents reviewed in this study generally were survivable within the envelope bounded by a line through an impact speed of 45 knots at an impact angle of 90 degreed, 60 knots at 45 degrees, and 75 knots at zero degrees.

(e) A potential 20 percent reduction in fatalities could be realized if all occupants of general aviation airplanes were to wear shoulder harnesses.

(f) Potentially, 88 percent of seriously injured occupants could be expected to incur significantly reduced injuries if shoulder harnesses were used.

(g) A potential 2 percent reduction in fatalities could be realized with the installation of energy-absorbing seats.

(h) Potentially, 34 percent of seriously injured occupants could be expected to have significantly reduced injuries if energy-absorbing seats were available.

(i) Where shoulder harness availability and use could be determined, only 16 percent of the occupants were wearing a shoulder harness at the time of the crash. Shoulder harnesses were available to 40 percent of the occupants and, when available, were worn 40 percent of the time.

(j) Twenty-seven percent of all seats in survivable accidents underwent some type of failure.

5.3.3 Phase Three - Acceleration And Velocity Changes Of Survivable Accidents

Over the years, many studies and dynamic tests have been conducted which attempted to define the limits of human tolerance to abrupt acceleration. Many of these studies used automobile crash data, which describe primarily single-axis loading (longitudinal). Automobile crashes also are of relatively low energy compared to airplane crashes. In the dynamic tests, the live occupants were completely restrained, including their limbs, which allowed them to sustain greater acceleration loads than could be tolerated by occupants restrained only by a lapbelt and single-shoulder harness. Also, most of these tests with live occupants used a single-axis load application and were stopped at a point where the loads approached the limits of pain or reversible injury. The conclusions from these studies and tests have helped define the limits of human tolerance to abrupt acceleration, but they do not describe adequately the severe but survivable crash environment of general aviation airplanes.

Unlike manay automobile crashes or the tests performed as a part of studies, airplane crashes are high-energy crashes which generate acceleration loads that can considerably exceed the limits of pain or reversible injury, and which act along many axes simultaneously. The restaint systems that are and will be used in general aviation in the future cannot approach the capabilities of the totally restrictive restaints that have been used in the dynamic tests with live occupants. Instead, the restraints of choice probably will be the lapbelt and the single, diagonal shoulder harness, comparable to those used in automobiles.

Since existing data defining the limits of human tolerance to abrupt accelerations do not adequately represent the crash environment of small airplanes, the Safety Board examined a number of general aviation airplane crashes in an attempt to define the limits of likely peak acceleration loads and velocity changes of survivable crashes. It is important to note that the occupant tolerance to acceleration, as presented in this Phase Three study, may apply only to general aviation airplane crashes, with the limiting factors being the crashworthiness of the fuselage structure and the multi-axis loading on the occupants.

Summary Of Results - Analysis of the selected 39 general aviation airplane crashes revealed that survival could be expected in crashes in which the longitudinal acceleration loads were in the 30 to 35 G range, with a velocity change to 60 to 70 feet per second. In the vertical direction, the acceleration loads were in the 25 to 30 G range with a velocity change to 50 to 60 feet per second.

There are significant differences in how the longitudinal and vertical load affect the occupant. An occupant can withstand a 30 to 35 G longitudinal load and sustain only minor injuries, as long as the severity of the secondary impact into the instrument panel or other objects is limited. In the vertical direction, the occupant can survive the 25 to 30 G load, but usually sustains severe injury to the back or neck (paraplegic or quadriplegic injuries). Thus, the vertical loads must be attenuated to a greater degree than the longitudinal loads if the occupant is to escape major crippling injuries.

The impact scenarios described in the Phase Three study conform to the basic definition of a survivable crash. However, certain design factors limit the ability of current airplane structures to provide crash protection. These include (1) the present shoulder harness systems which cannot preclude occupant contact with the instrument panel in the more severe accidents; and(2) the airplane structure which cannot absorb relatively high crash loads without collapsing, thus limiting the occupiable area that protects the occupant. The next major advance in crashworthiness protection may well come from more effective fuselage design (7).

Selectivity - Accidents selected for this study were severe, but survivable. One guideline used for the selection of accidents was that the accident had to have a serious or fatal injury and had to have at least one survivor. Accidents involving fire were rejected unless the fire was very minor.

Crashworthiness investigations were conducted on 39 accidents, one of which was determined to be nonsurvivable. Nineteen accidents had at least one fatality and 18 accidents had no fatalities but had one or more seriously injured occupants. In two accidents the occupants had only minor injuries, but these accidents were included because of the severity of the impact.

Methodology - The methodology described briefly here and more completely in the Phase One report was used to calculate acceleration loads and velocity changes. Data were evaluated that led to conclusions about impact angles, impact speeds, and stopping distances for the airplanes. Acceleration loads the velocity changes were calculated when sufficient data exists.

When a range of values was possible for a parameter, the most conservative values were used. This established minimum acceleration load for those cases in which more precise acceleration loads could not be calculated. In many of these cases, even the conservative aceleration loads greatly exceeded the current FAA design requirement of 9 G's.

Validity Of Data Base - It was important to establish that the accidents used for this study represented the more severe, survivable general aviation accidents so that the upper bounds of the survivable envelope could be better defined. To test the selection process, the data in this study were compared to the data presented in the Phase Two report. Figure 5-10 depicts the impact angles and impact speeds of the accidents that were selected for this study were compared to the NASA crash test data and the 1982 NTSB data that was the basis for the Phase Two report. It was determined that the 39 accidents represented severe, but survivable general aviation crashes.

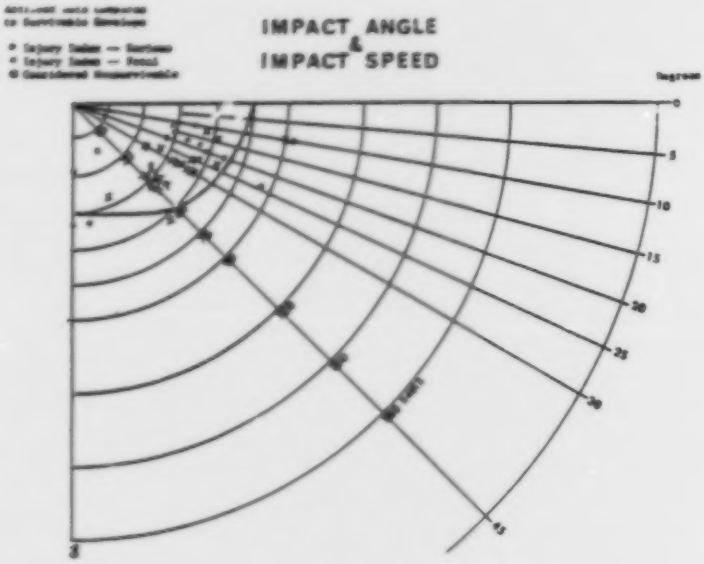

Figure 5-10. Impact Angle and Impact Speed of the Accident Cases Compared to the Survivable Envelope

A second comparison between the Phase Two and Phase Three data was made showing the relative availability and use of shoulder harnesses and energy-absorbing seats and the potential reduction in injuries through their use. The two data sets compared favorably Table 5-4. Although qualitative in nature, a third comparison of both the airplane damage and general injury level of the two sets of accidents was made. The amounts and types of damage to each airplane and the severity of injuries to the occupants in the Phase Three data set were found to be consistant with the Phase Three data set.

Table 5-4. Comparison of Data from the Phase Two Study and the Phase Three Study

	Phase Two	Phase Three
Accidents	535	39
Occupants	1,268	118
Survivable Crashes	59 percent	97 percent
Fatally Injured Occupants	800 (216 in survivable accident)	27 (23 in survivable accident)
Seriously Injured Occupants	229	65
Minor/None Injured Occupants	87	27
Fatally Injured Who Would Have Survived With Shoulder Harness Use	75%	65%
Seriously Injured Who Would Have Benefited From Shoulder Harness Use	88%	77%
Seriously Injured Who Would Have Benefited From Energy-Absorbing Seat Use	34%	24%
Shoulder Harness Available	40%	32%
Shoulder Harness Use (if available)	40%	45%
Shoulder Harness Overall Use	16%	14%

Evaluation Of The Acceleration And Velocity Change

Longitudinal Acceleration and Velocity Changes - Acceleration loads and velocity changes are expressed in relation to the airplane's axes. They could not be calculated for all cases because of missing data, such as impact velocity, stopping distances, and/or long slides after impact. The upper limit of the range of acceleration loads in these survivable accidents is 30 to 35 G's and the upper limit of the range of velocity change is 60 to 70 feet per second.

In two cases, the velocity changes were over 80 feet per second, but they were not typical cases. In one case, the airplane flew into a grove of trees, came to a stop, and remained suspended in the trees with no injury to the occupant. The second case involved a straight-down impact which was nonsurvivable for the front seat occupants because of the crushing.

Based on the extent of airframe damage and the severity of injuries, velocity changes greater than 60 feet per second were judged to approach the upper limits of survivability. In the most severe of the survivable cases, shoulder harness use did not always prevent the occupants from contacting the instrument panel. Because of inadequate shoulder harness adjustment and material stretch, either the occupants were able to move forward too far, or severe airframe crushing caused the instrument panel to move aft a significant distance, thus compromising the potential of shoulder harness use.

Vertical Acceleration and Velocity Changes - The vertical acceleration loads and velocity changes were calculated for 12 of the 39 accidents. Accleration loads or velocity changes could not be calculated for all cases because of missing data, such as impact velocity and/or impact angle. The upper limit of the range of survivable acceleration loads approached 25 to 30 G's and the corresponding velocity changes were in the 50 to 60 feet per second range.

For two of the cases in which energy-absorbing seats were used, acceleration levels were calculated for both the fuselage and the occupants. The occupant acceleration calculations are identical to the fuselage acceleration calculations except that the stopping distance of the occupant is increased by the stroking distance of the seat; this decreases the acceleration level of the occupants. In one case, the seat stroked about 6 inches, decreasing the acceleration level of the occupant from 24 G's to 18 G's. In another case, both seats stroked their full travel of about 1 foot. This decreased the acceleration level of a 180-pound occupant from about 36 G's to 18 G's. The seat did not bottom out and therefore safely dissipated the occupant's energy. However, the other occupant, a 270-pound male, sustained fatal spine/skull injuries when his seat bottomed out against the floor, creating a large, fatal acceleration spike. Thus, the weight of an occupant in an energy-absorbing seat is an important factor in the amount of protection provided by the seat.

This relationship can be described as follows. An energy-absorbing seat would stroke at a constant force exerted by the occupant. A seat that strokes at 2,000 pounds would be a 20 G seat for 100 pound occupant (2,000/100) and it would be a 10 G seat for a 200 pound occupant. A seat that can stroke 1 foot at 2,000 pounds can slow a 100 pound occupant from 36 feet per second to zero feet per second, but that same seat can slow a 200 pound occupant only from 36 feet per second to 25 feet per second. The seat dissipated most of the energy of the lighter occupant, whereas the heavier occupant still was moving at a relatively high velocity when the seat's stroking capability was expended and he contacted the floor.

Occupant Injury and Seat/Restraint System Design

With a single exception, all of the crashes discussed in the Phase Three report were survivable. In some of those cases, the occupants were provided good crash protection by properly designed seats and restraints. Those seat/restraint systems greatly exceeded the current design requirements of the Federal regulations. However, many occupants were needlessly injured

because seat/restraint systems either were not able to structurally withstand the crash loads, shoulder harnesses were not available, or they were not used. Most of those injuries could have been prevented if the seat/restraint systems had been built to withstand more realistic dynamic crash loads, or if the occupants had used shoulder harnesses.

During the investigations of these accidents, many seat and restraint problems were documented. These included problems with seat strength, seat feet design, lack of energy absorption capability, inadequately designed seat pans, lack of shoulder harness installation or use, and equipment that was added to seats. Another recurring factor was failure to use the installed shoulder harnesses.

Restraints-Shoulder Harness And Lapbelts

In survivable accidents, the most commonly seen injuries of a severe nature are to the head or upper torso. The Phase Two report established that 20 percent of the fatally injured and 88 percent of the seriously injured occupants had serious but preventable head and upper body injuries and that only 16 percent of the occupants were wearing shoulder harneses. Almost all case studies in this report show examples of head and upper body injuries that could have been prevented with the use of upper body restraints. Shoulder harness use not only prevents or minimizes head and upper body injury, but the harness can redistribute a large portion of the crash loads to the upper body so that the lapbelt and pelvic loads are less. High lapbelt loads can cause pelvic and internal injuries.

In many cases, shoulder harnesses were not worn by the occupants for one of two reasons, either they were not available or passengers were not required to wear them. The Phase Two report established that shoulder harnesses were available only in 40 percent of the front seats of the general aviation airplanes examined and that they were almost nonexistent in rear seats.

Further, only 40 percent of the occupants were wearing their available harnesses when an accident occurred.

Several pilots who were wearing their restraints for takeoff stated that they removed the shoulder harness portion of the restraint after the takeoff was completed. When an emergency occurred, they did not remember to put the harness back on. In four other accidents in which shoulder harnesses were not available, rear seat occupants sustained fatal injuries because of head strikes or fractured or dislocated cervical vertebrae which could have been avoided if shoulder harnesses had been available and worn.

Shoulder harnesses provide additional protection during an accident. Without a shoulder harness, the entire occupant load is carried by the lapbelt. That can create excessive belt loads to the pelvic and abdominal regions of the body. Occupants received injuries consistent with high lapbelt loads. Typical injuries were fractures of the pelvis, tears of internal organs, and tears of the soft tissue of the lower abdominal area.

In survivable crashes, restraint systems sometimes separate because they are required only to meet the static test loads described in 14 CFR Part 23. The more severe, survivable crashes generate forces that easily can exceed these levels by a factor of two or three. One case involved a Piper Model PA32 airplane that used cables to attach the rear lapbelts to the floor. Two of the cables broke, causing the occupants to sustain more serious injuries than expected. In 1973, the Safety Board issued to the FAA Safety Recommendation A-73-59 recommending that it require the owners to replace the existing lapbelts attachment cables with stronger cables. It was believed that the cable was under-designed and that extra streses were imparted to the cable as it bent around the seat frame. The FAA declined to implement the recommendation, stating that the crash exceeded the design standards applicable to that airplane. Shortly after this accident, another crash occurred involving a Piper airplane in which the rear lapbelt cable broke. The occupant, who was not restrained because the cable broke, probably sustained more serious injuries than if the lapbelt had held. All of the cables that broke were 1/8 inch in diameter and were in airplanes manufactured before 1973, the year Piper upgraded a 3/16 inch cable. Each cable exhibited signs of breaking due to static overload and additionally, one cable was corroded. The corrosion weakened that cable, but it still would have met the current design requirements. Cable breaks and lapbelt separations typically have not been a problem in survivable crashes in which other designs have been used.

In another case, the pilot's lapbelt attachment separated, allowing the occupant to hit the panel with his whole body. The bolt that holds the attachment in place was pulled out when the cabin deformed, causing the fitting to twist and shear the attachment bolt.

Seats And Restraints-Dynamic Testing

Design and test requirements for general aviation seats are not adequate because the required static test procedures do not adequately prove the capabilities of the seat/restraint designs. Seats that meet the current requirements may offer little protection in a crash because they are understrength or they may not perform properly in an actual crash environment. It was found that present test load applications are not realistic and that the design load requirements are too low. For example, a seat with the lapbelt attached to the floor may weigh about 20 pounds, thus requiring a static pull test of 180 pounds to the seat (9 G's times 20 pounds). The body block, on the seat and restrained by a belt, would be subjected to a force of (9 times 170) 1,530 pounds. The test requirements also allow simultaneous forward and upward loads, which prevent the body block from pushing down on the seat in a manner more representative of an actual airplane impact condition. In an actual crash, a seat may come off the tracks or may break at less than 9 G's since the body normally moves down and forward during a crash. When this happens, the seatpan deflects, allowing the pelvis to move below the seatframe which causes the body's weight to load the front of the seat (1,530 pounds at 9 G's). This event can occur even before the lapbelt restraint becomes effective. This scenario causes the seat to be loaded quickly in excess of its 180 pound design limit; the seat, therefore, is most likely to break or separate from its tracks.

Another problem typically encountered in crashes, and which is not accounted for in current design practices, is overshoot. Overshoot is a phenomenon in which the occupant acceleration is greater than the airplane crash acceleration. Overshoot occurs when the occupant is accelerated and then stopped abruptly by the lapbelt or shoulder harness; it is similar to the high occupant acceleration load being generated by secondary impact into the instrument panel. A seat/restraint system can be tested to 9 G's equivalent static load, but in an actual 9 G crash, overshoot may generate loads that are 1.5 to 3 times greater, significantly greater than the static test loads. This problem is more severe for systems that have the restraints attached to the seats. The extra loads created by overshoot may cause the entire seat/restraint/occupant system to become detached from the airplane structure. To be assured that a seat/restraint system meets any prescribed load, the system must be dynamically tested, and the loads applied in proper directions.

Because shoulder harnesses are optional, seats and lapbelts in combination or of themselves must accommodate the loads prescribed by 14 CFR 23.561. However, since a shoulder harness can transfer large loads directly to the fuselage, it is possible that, in a particular seat/lapbelt/shoulder harness system, the shoulder harness could carry a large portion of the prescribed 9 G load. When the installation and use of shoulder harnesses are made mandatory, designers will be in a position to reduce the strength of the seat/lapbelt combination and meet the standard on the basis that the combined seat/lapbelt/ harness system accommodates the prescribed load. For instance, for certification purposes as a 9G system, a lapbelt could be designed to sustain a 6 G load and the shoulder harness could be designed to sustain the remaining 3 G load. At least one manufacturer designed and tested a seat using multiple loads and later found that a single axis forward pull test would fail the seat. Rather than redesign the seat, the solution was to require the use of a shoulder harness and use the contribution of the shoulder harness to meet the 9 G requirement. When shoulder harness use is not required or when the crew or passengers forget to put the harnesses back on during the emergency, a 6 G seat does not offer the expected protection. The Safety Board believes that the seat/lapbelt combination of itself should continue to be required to handle the prescribed load, as should the entire seat/lapbelt/shoulder harness system.

Seat Feet And Seat Legs - Many of the seats in the general aviation fleet break or come off the tracks during survivable crashes. The cases in this study showed that 44 percent of the occupied seats became detached from the airplane structure, usually because the seat feet or legs broke or separated. In one case, a seat came loose, which allowed the occupant, who had survivable injuries, to fall out of the airplane and drown in shallow water. Had the seat remained in place, the occupant would have been held in place by the lapbelt.

In another case, the seat frame strength was inadequate. There were no braces between the front and aft legs of the seat and since the front legs had adjustment pins in the tracks, they resisted all of the forward loads exerted on the seat during the crash. As the seat was forced to move forward, the frame bent allowing the rear legs to move closer to the front legs. When the frame broke, the rear legs were free to move forward on the tracks until they contacted the front legs. During this process, the rear of the seat rotated down accelerating the occupant toward the floor.

Many of the seats separate because of small side loads to the seat coupled with the warping of the floor and seat tracks. Seat separations because of side loads are directly related to low side load test requirements. The side load requirement of 1.5 G's is totally inadequate. With a misalignment of only 10 degrees, a 9 G forward acceleration can create a side load of 1.5 G to the seat feet. Small side loads can result in seat separation because the seat feet spread. The combat this problem, several manufacturers have added extra structure to the seat foot area. Beech Aircraft has designed an extra bracket for the seat feet in their Model 23 series of airplanes, and Piper Aircraft has recommended adding two large washers to each seat foot in many of the PA-28 series of its airplanes.

Floor warping can cause seats to fail. As a floor warps, extra stresses can be placed on the seat feet as the seat resists changing its original shape to accommodate the floor warp. Piper designed an energy-absorbing seat that is flexible in several directions. The seat can stroke vertically, which absorbs energy, but it can distort and twist also without much resistance. With that built-in flexibility, the Piper "S" tube seat can deform to the contour to the floor warp without causing excessive stress on the seat feet.

Other cases involved seats that were struck by the occupants who were seated directly behind them. When a seat is struck from behind, it has to carry the loads of its own occupant and the additional loads of the occupant behind. This type of extra loading is not considered in any current design practice.

Multi-axis dynamic testing of seats can uncover these types of design problems. Higher strength requirements would ensure that the seats would not break when exposed to minor loads.

Energy-Absorbing Seats

Energy-absorbing seats are needed to dissipate excess energy and prevent lower back and pelvic injuries. The Phase Two report concluded that 34 percent of all seriously injured occupants could be expected to have had significantly less serious injuries if energy-absorbing seats had been installed. Twenty-nine of the occupants in this study (24 percent of the total occupants) did benefit or would have benefited from the use of energy-absorbing seats.

An allowance for vertical stroking distance is a primary requirement if an energy-absorbing seat is to perform its function. Little or no room is provided for vertical stroking of the back seats in some of the smaller general aviation airplanes. Many of the rear seats are mounted on the floorboards so that the occupant is seated only in inch or two above solid structure. In one case, a 3/4 inch plywood floor covered several inches of space that was available for stroking. During the high vertical loading experienced in this accident, the occupant bottomed out on the plywood floor and sustained a broken back. In another case, the second row of seats was placed on structure that houses components of the air conditioning system. There was no room for the seatpan to move down, and the occupant bottomed out on the structure, sustaining a broken back.

Only one seat in general aviation airplanes is designed as an energy-absorbing seat. The Piper "S" tube seat offers a significant amount of protection by absorbing energy in a controlled manner as it deforms and deflects toward the floor. This seat was dynamically tested to fine tune its energy absorption characteristics. There are other seats designed in the early 1960's that can absorb energy, even though that was not a part of the design criteria. For instance, the front seats in the Beech Sport/Sundowner series airplanes, can absorb significant crash loads.

Seatpan Design - One of the least discussed components in seat/ restraint system design is the seatpan. The seatpan can perform the important function of absorbing energy in the vertical direction through deflection or by transmitting the occupant loads to the seat frame. However, design requirements for the seatpan are almost nonexistent.

There were seatpans that separated incrementally, absorbing energy in the process. They consisted of formed aluminum sheets that were attached to the steel tube seat frames by rivets. As the pilot and copilot moved downward, the aluminum seatpans began to tear away from the rivets sequentially. Although the seats did not stroke, the tearing seatpans increased the stopping distance of the crewmembers in a relatively controlled manner, which resulted in less severe acceleration loads on their spines.

Seatpans can tear in a catastrophic manner. In one case, they separated, causing the occupants to bottom out on the floor. The tie-wires that stabilize the seatpan springs came detached and allowed the springs to spread apart. The occupants moved down through the springs to the floor. In another case, the nylon fabric seatpan tore, allowing the occupant to contact the floor. During the investigation, a small tear was found in the seatpan of the unoccupied right front seat. By pulling at the tear with one finger, the tear was propagated along one side of the seatpan. The material appeared to be strong, but the tear resistance was minimal while the material was under tension, acting as a diaphram. Once the material was torn enough to ease the tension, it could no longer be torn by hand. It is believed that the loads on the occupied seat were high and that a tear started in the pan and propagated with little resistance.

Another seatpan exhibited characteristics similar to the ones discussed above. The seat was over air conditioning ducting which limited vertical movement. However, there were two small holes in the nylon mesh seatpan. During the investigation, the seatpan was torn by pulling at the holes with a finger. The pan could be torn in that manner until it no longer was in tension.

The seatpans in another case presented additional problems. The pans were made from a neoprene material that had deterioriated with age. Although the crash generated relatively minor loads in the vertical direction, the seatpans had separated at the steel fittings and were held in place only by the foam rubber comfort cushions.

The Safety Board believes that more stringent design requirements, such as dynamic testing, would have precluded the production of these poor seatpan designs. Evaluation of the rip-stop capabilities of seatpan material may be in order, as would be an evaluation of the effects of seatpan deterioration with age.

Seat Add-Ons - Present general aviation airplane seats generally do not exceed greatly the minimum FAA strength requirements and they do not offer much protection to occupants in more than a minor crash. Attaching additional equipment to the seat adds extra weight and further degrades their protection capabilities.

There were cases where equipment had been added to the seats. One oxygen bottle supplier advertises oxygen bottle holders that can hang over the backs of the front seats. These holders have three negative aspects: first, the system can add as much as 20 pounds, which decreases the seat's G-load capabilities. Second, the positioning is dangerous because, in a crash, the bottle could drive into the head or back of the front seat occupant. Third, a rear seat occupant could pitch forward and contact the unpadded bottle.

The drilling or modification of a seat frame is another problem related to adding equipment to seats. Field modification procedures that are acceptable for other airplane structures are not acceptable for seats. This is because the stresses and load paths in seat structures are far more complicated than on other airplane structures on which field modifications are permitted. Any modifications to seat structures should comply with the more rigorous requirements that apply to the primary airplane structure, such as wing spars or engine mounts. The drilling of holes or other modifications of seats have been demonstrated by dynamic testing to have potentially disastrous effects.

Attaching or storing objects under a seat also may prevent a seat from stroking in the vertical direction, thus negating any potential energy-absorbing benefits that the seat might provide. For example, fire extinguishers are often stored under the front seats which results in a reduction of the seat stroke distance by as much as four inches.

Improper seat modifications or seats in poor repair can be overlooked by a mechanic. In one, the seatpans had been removed and replaced with lawnchair webbing which was fastened with the kind of staples used for paper. Deteriorated seatpans were not discovered during normal inspections. Analysis of the material indicated that the deteriorated condition of the seatpan material was of long standing.

Although in this study there were no injuries that could be attributed to a seat add-on equipment, the person in the seat with lawn chair webbing did sustain a serious back injury. These problems do not appear widespread; nevertheless, the Safety Board believes that better education of the aviation community about the critical nature of general aviation airplane seats and the need to improve them is warranted.

Conclusions - Phase Three

1. The accidents in this study were severe, but survivable, general aviation airplane crashes.

2. Acceleration loads and velocity changes of 30 to 35 G's and 60 to 70 feet per second in the longitudinal direction are generally survivable.

3. Acceleration loads and velocity changes of 25 to 30 G's and 50 to 60 feet per second in the vertical direction are generally survivable but the loads experienced by the occupants must be limited to a lower level to prevent crippling injuries to the back and neck.

4. The impact severities (angles and speeds) of the cases in this study closely match the impact severities of the NASA crash tests.

5. The current seat design requirements of 9 G's forward and 3 to 6 G's downward are inadequate.

6. The practical limits of survivability in general aviation airplane crashes are governed by the type of seat/ restraint systems used and the capability of the fuselage structure to withstand acceleration loads.

7. Based on the results of this study, a dynamic seat/ restraint system test to 26 G's and 42 feet per second velocity change longitudinally appears to be reasonable and appropriate.

8. A dynamic test seat/restraint to 19 G's and 31 feet per second velocity change vertically represents a minimal level of protection, but many occupants will be protected in seats designed to this standard. If the manufacturers also were to use available stroking distances effectively, most occupants will be protected in survivable accidents.

9. Many occupants in airplane accidents would derive substantial benefits from seat/restraint systems designed to GASP standards, even if the impact loads were more severe than the prescribed test loads.

10. Head impacts into the instrument panel cannot be precluded, even with properly designed restraint systems. The GASP requirements for the use of a Head Injury Criteria (HIC) test is important, if head impact to the panel is predicted during dynamic testing.

11. In the accidents analyzed part of this study, over 1/2 of the seats became detached in severe but survivable accidents. Current design requirements call for seat feet to withstand only very low side loads. Floor warpage also causes excessive stresses and separations in the feet of seats that cannot conform to the warpage.

12. Study data indicate that shoulder harnesses are not being used to the fullest extent, even when available. Only crewmembers are required to wear them for takeoff and landing, and many crewmembers fail to do so. In other cases, the occupants released the shoulder harnesses while en route and forgot to put them back on when an emergency arose.

13. Shoulder harness use can reduce the lapbelt loads, preventing many internal organ and pelvic injuries.

14. Shoulder harnesses should not be used to meet the 9 G longitudinal static load requirement for the entire occupant restraint system. Instead, each seat/lapbelt system should be require to restraint the occupant to 9 G's, i.e., the protection of a shoulder harness should be additive.

15. Energy-absorbing seats are necessary to prevent many of the spinal injuries that occur in survivable accidents.

16. Seatpan design requirements are needed to ensure that occupant loads are carried by proper structure. Seatpans should have rip-stop capabilities and should be designed so that they do not collapse catastrophically.

17. For most seats, add-on equipment should be prohibited because the added weight degrades the protection capability of the seat/restraint system.

18. Energy-absorbing seats, lapbelts, and shoulder harnesses should be designed as an integrated system so that the maximum advantage from each can be gained.

19. Unique features of some airplane seat/restraint designs can contribute to the failure of the systems at loads that would otherwise be tolerable. For example, seatbelts attachment cables have been shown to be the first element to break in some airplanes. Simple actions to install larger diameter cables would improve the seat strength in these airplanes.

20. Available stroking space must be efficiently utilized and not covered over with flooring and cabinetry materials.

5.3.4 Post Crash Fire

The data contained in the Phase Two study included a total of 128 accidents involving fires. These accidents involved 298 occupants, 249 of whom received fatal injuries. Additionally, at least 13 surviving occupants received serious thermal injuries. Two separate methods of evaluation were used in order to determine whether the crash or the subsequent fire caused the 249 fatalities. The intent was to eliminate nonsurvivable crashes and to identify only those fatalities in which fire rather than impact was the cause of death.

In the first method of evaluation, autopsy and impact data of each accident file were examined to determine the survivability of the accident preceding the fire. Less severe impact, soot in the trachea, and/or high carbon monoxide levels in the victims were indicators that a fire had occurred. More severe impact, no soot in the trachea, and/or significant blunt trauma injuries were indicative of fatal impact injuries regardless of the severity of subsequent fire injuries. By determining accident survivability with respect to these criteria, it was estimated that 32 to 44 lives could have been saved if fires had been prevented. Additionally, 13 surviving occupants would not have sustained serious thermal injuries as a result of the post-crash fire.

In the second method of determining fire related deaths, it was assumed that fires and impact severity were related. That is, it was assumed that the likelihood of encountering a fatality as well as a fire increased with the severity of the impact.

The basic 1982 data were divided into four groups of impact severity. Group one (1) impacts were those accidents with impact angles of less than 45 degrees and with impact speeds of less than 75 knots. Group two (2) impacts included those accidents with less than 45 degree impact angles but with impact speeds greater than 75 knots. Group three (3) included accidents with impact angles greater than 45 degrees and impact speeds of less than 60 knots, and group four (4) accidents included impact angles that were greater than 45 degrees but with impact speeds greater than 60 knots.

Within each group, the fatality rate (% fatal) was calculated for fire and non-fire accidents. In the less severe impact groups (1) and (3), the fatality rates were greater when there was a fire. In the more severe impact groups (2) and (4), the fatality rates were similar whether a fire was present or not. This suggests that, in the severe accidents, the crash force is the primary cause of death rather than the fire. This trend also was seen in the analyses conducted using the first evaluation method.

The fatality rates of the fire and the non-fire accidents of each severity group can be compared to illustrate the magnitude of the fire problem. For example, Group (3) impacts are at low speed and at steep angles. The fatality rates of fire and non-fire accidents in this group are 82 percent and 70 percent respectively. If it is assumed that the difference in the fatality rates is due to fire, then 12 percent of the occupants suffered a fire death. For Group (3), there were 34 occupants in fire accidents and 12 percent of those, or 4 occupants, would be expected to have been fire deaths. The final results, as seen in Table 5-5, yield an estimated 26 fire deaths for this evaluation method.

Table 5-5

Severity Group	Fire	Non-Fire
(1)	(64%	- 40%) X 72 = 17
(2)	(87%	- 82%) X 76 = 4
(3)	(82%	- 70%) X 34 = 4
(4)	(100%)	0 99%) X 75 = 1
		26

The predicted 26 fire deaths are based on 80% of the fire accidents since impact data were not available for the remaining 20%. Correcting the predicted fatalities to the total data base, a total of 32 fire deaths would be expected to have occurred in 1982.

In summary, about 14 percent of the fatally injured occupants in fire accidents evaluated above could have survived had there been no fire. That translates to about a 4 percent yearly reduction in fatalities in all general aviation airplane crashes in post-crash fires were prevented in survivable crashes. Additionally, about 26% of the seriously injured occupants in accidents with the fire could have been injured less severely had there been no fire which represents about a 6 percent yearly reduction in serious injuries.

The Safety Board believes that the predicted four percent reduction in fatalities by averting fires is a absolute minimum based on a conservative analysis of the accidents. The anticipated improvements through other crashworthiness rulemaking efforts, such as the addition of dynamically tested seat/shoulder harness systems and energy-absorbing seats, may expand the survivable envelope of general aviation airplane accidents so that more occupants will survive the impact. These anticipated improvements will increase the number of occupants who will be exposed to post-crash fires which further warrants rulemaking in this area.

BIBLIOGRAPHY - ACCIDENT ANALYSIS

1. H. DeHaven, "Injuries in Thirty Light Aircraft Accidents. Medical Data and Crash Details from Field Investigations of the Civil Aeronautics Board", National Research Council, Division of Medical Sciences, Committee on Aviation Medicine, Report No. 230, November 17, 1943.

2. H. DeHaven, "Injury in Light Aircraft Accidents", The Air Surgeon's Bulletin, Volume 1, 1944, page 5.

3. H. DeHaven, "The Relationship of Injuries to Structure in Survivable Aircraft Accidents", National Research Council, Committee on Aviation Medicine, Report No. 440, July 9, 1945.

4. D.J. Marrow, "Analysis of Injuries of 1942 Persons in 1442 Light Plane Accidents", CAA Medical Service Records, Washington, D.C., unpublished data, 1949.

5. H. DeHaven, "Packaging the Passenger", Society of Automotive Engineers Journal, 60:55-56, June 1952.

6. A.H. Hasbrook, "Severity and Injury in Light Plane Accidents: A Study of Injury Rate, Aircaft Damage, Accident Severity, Impact Angle, and Impact AV-CIR-6-55-105, September 1959.

7. A.M. Eiband, S.H. Simpkinson, and D.O. Black, "Accelerations and Passenger Harness Loads Measured in Full-Scale Light-Airplane Crashes", National Advisory Committee for Aeronautics, Technical Note 2991, 1953.

8. E.F. DuBois, "Limited of Factors of Safety in the Human Body", Mechanical Engineering, Volume 68, January 1946.

9. R.G. Snyder, "Civil Aircraft Restraint Systems: State-of-the-Art Evaluation of Standards, Experimental Data, and Accident Experiences, "Society of Automotive Engineers, Inc., International Automotive Engineering Congress and Exposition, Detroit Michigan, Paper Number 770154, March 1977.

10. The Status of General Aviation Crashworthiness NTSB Report SR-80-2 Appendix B Safety Board Crashworthiness Investigations of 14 General Aviation Accidents in 1979, December 17, 1980.

11. Aircraft Crash Survival Design Guide, USARTL-TR-79-22, Applied Technology Laboratory, U.S. Army Research and Technology Laboratories (AVRADCOM), Fort Eustis, Virginia, 1980.

12. Vaughn, V.L. Jr., and R.J. Hayduk, "Crash Tests of Four Identical High - Wing Single - Engine Airplanes," NASA Technical Paper 1699, August 1980; and, "Determination of Crash Test Pulses and Their Application; "To Aircraft Seat Analysis," Society of Automotive Engineers, Inc. Technical Paper 810611, April 1981.

6. CANADIAN AVIATION ACCIDENT/INVESTIGATION AND ANALYSES

6.1 Introduction

The Canadian Aviation Safety Board (CASB) has as its overall objective the promotion of the adoption of aviation safety recommendations by regulatory agencies and the aviation community.

Specific objectives as they relate to crashworthiness fall under two major programs within the Board:

A. Aviation Safety Engineering

- "the ongoing development of standards and conduct of research designed to approve procedures and techniques employed in support of the investigative process"; and

B. Aviation Safety Medicine

- "the ongoing conduct of research into human performance factors as they relate to aviation occurrences";

- "the ongoing development of standards and conduct of research designed to improve procedures and techniques employed in support of the investigative process".

The CASB has not, with the exception of an effort discontinued in the early 1980's (described in 6-5 below), carried out any specific accident analysis work related to small aircraft crashworthiness.

6.2 Accident Investigation Activities

Investigation of all aviation accidents/incidents in Canada is conducted by the Canadian Aviation Safety Board. The investigation report is placed in a computerized data storage and retrieval system called the Canadian Accident/Incident Data System (CAIDS). The CAIDS system is based on the accident data reporting system developed by the International Civil Aviation Organization (ICAO). CAIDS was implemented in the spring of 1976 and contains accidents and incidents which occured after January 1, 1976.

A copy of the "Report of Investigation of an Aircraft Accident/ Incident" form has been included in Appendix 2. A copy of a computerized accident data report has been included in Appendix 3. Page 12 of the accident data relates to wreckage and impact information. The terrain surface is identified, as are the roll, pitch, and yaw upon impact of the aircraft. The investigator indicates whether the damage to various aircraft components

was severe, moderate or minor. The components covered are the aircraft as a whole, the cockpit, forward cabin, center cabin, and aft cabin. The report identifies whether seatbelts were present in the aircraft, and whether they were fastened at the time of impact.

The investigator identifies whether the crash was survivable or non-survivable. There is, however, no definition for a "survivable" crash. The investigator uses his judgement, and, according to a CASB official, most fatal accidents are automatically classified as "non-survivable".

By comparison, the U.S. "Factual Report Aviation Accident/Incident" form, included as Appendix 1, is 63 pages long. It includes a special supplement (Supplement I) on crash kinematics. Terrain, airspeed at impact, pitch, roll, and yaw attitudes are specifically identified. Cockpit and cabin damage are reported as "destroyed", "collapsed", "part collapsed", "distorted", "burnt", "intact" or "none". The investigator must include a sketch of the crash kinematics.

The U.S. accident/incident report form contains a further supplement (Supplement L) which specifically identifies seat, restraint system, and fuselage deformation which are used to determine survivability and crashworthiness of the aircraft.

6.3 Definition Of Accident/Incident

The definitions of "accident" and "incident" are provided in the Canadian Aviation Safety Board Regulations, pursuant to the Canadian Aviation Safety Board Act. The definitions in the CASB Regulations are as follows:

> "accident" means any aviation occurrence where, at any time during the period commencing when the first person boards an aircraft for the purpose of flight and ending when the last person disembarks from the aircraft after the flight,
>
> (a) a person, other than a stowaway, sustains a serious injury or fatal injury, that is not self-inflicted or inflicted by another person or caused by natural causes, as a result of that person
>
> (i) being in the aircraft;
>
> (ii) coming into dirct contact with any part of the aircraft, including any part that may have become detached from the aircraft, or
>
> (iii) being directly exposed to the jet blast of the aircraft,
>
> (b) the aircraft sustains damage or structural failure adversely affecting the structural strength, performance
>
> (c) the aircraft fails to remain within the intended landing or take-off area, lands with one or more landing gear retracted, or drags a wing tip or engine pod,

(d) any crew member is unable to perform his flight duties as a result of incapacitation,

(e) decompression, explosive or otherwise, occurs that necessitates an emergency descent,

(f) a fuel shortage occurs that necessitates a diversion or requires approach and landing priority at the destination of the aircraft,

(g) the aircraft is refuelled with the incorrect type of fuel or contaminated fuel that is undetected prior to departure from the ramp,

(h) a collision or risk of collision with any other aircraft or with any vehicle, terrain or obstacle occurs, including a collision or risk of collision that may be related to air traffic control procedures or equipment failures,

(i) a flight crew member declares an emergency or indicates any degree of emergency that requires priority handling by an air traffic control unit or the standing by of crash, fire fighting or rescue services, or

(j) toxic gases or corrosive materials leak from any cargo aboard the aircraft;

"incident" means an aviation occurrence, other than an accident, that affects or could affect the safe operation of an aircraft".

6.4 Definition Of Accident Injury

The injury index is identified on page 3 of the Report of Investigation of An Accident/incident. The categories are "fatal", "serious injury", "minor injury" and "no injury". The first two categories are defined in the CASB Regulations as follows:

A "fatal injury" means an injury that is sustained by a person in an accident that results in death within 30 days of the accident.

"Serious injury" means an injury that is sustained by a person in an accident and that

(a) requires hospitalization for more than 48 hours, commencing within seven days from the date the injury was sustained,

(b) results in a fracture of any bone, other than a simple fracture of the nose or of any fingers or toes,

(c) involves lacerations that cause severe haemorrhage or nerve, muscle or tendon damage,

(c) involves lacerations that cause severe hemorrhage or nerve, muscle or tendon damage,

(d) involves injury to any internal organ, or

(e) involves second or third degree burns, or any burns affecting more than fire percent of the body surface.

There is no definition for a minor injury. In public reports of aircraft accidents, no distinction is made between "minor injury" and "no injury". The investigator must use his discretion on identifying minor injuries.

6.5 Investigator Training - Crash Survival

The Canadian aviation accident investigators are well trained in crash safety concepts. All investigators attend a 2-week course in "Crash Survival Investigation" in Tempe, Arizona. The objective of the course is to provide knowledge in the investigation and evaluation of the survival and crash injury aspects of aircraft accidents, the development of general aviation education and injury prevention programs, and the evaluation of the design of the aircraft and its sub-systems in terms of crash safety.

An 11-week advanced crash survival investigation course also is available to the accident investigators in CASB.

6.6 Emphasis On Crashworthiness In CASB

In the early 1980's, crashworthiness was a high priority in aircraft accident investigation. A special 4-page supplementary form was developed (a copy has been included in Appendix 4) which included data gathering an aircraft kinetics (velocities, impact angle, flight path/terrain angle, and so on), deformation of various components of the aircraft, crashworthiness systems available/used by the aircraft occupants, and a description of injuries.

This form was used by the accident investigators on a voluntary basis. As the recent emphasis has shifted away from crashworthiness, the optional crashworthiness form has fallen into disuse.

6.7 Current Studies On Canadian Crashworthiness

As has been the case in the U.S., the Canadian Aviation Safety Bureau has a growing concern over restraint systems in aircraft. Both seat restraints and baggage restraints are being reviewed by CASB. Pilots are required to wear at least a lap belt, but the belt must be done up only for landings and take-offs. Several incidents have occurred where seat belts have broken away from the aircraft structure.

The Safety Programs Branch is currently conducting a study on the use of seatbelts and the impact of their use on aircraft injuries. The study involves small aircraft under 12,500 lbs.

The study is currently ongoing, although an incomplete Canadian database (only 60% of accident investigation reports indicated whether seatbelts were available/fastened) is making conclusions difficult.

7. CRASHWORTHINESS RESEARCH ACTIVITIES - UNITED STATES

7.1 Pre-1979[1]

Occupant crash protection has been of concern to aviation researchers for more than 40 years. In 1944, the National Research Council (NRC) analyzed the causes of injuries in light aircraft accidents and concluded that the "safe transportation of people in any type of vehicle must of necessity apply the practical principles which are used by every packaging engineer to protect goods in transit." (1). The principles advocated were:

1. The package should not open and spill its contents and should not collapse under reasonable or expected conditions of force and thereby expose objects inside to damage.

2. Packaging structures which shield the inner container must not be made of brittle or frail materials; they should resist force by yielding and absorbing energy applied to the outer container so as to cushion and distribute impact and thereby protect the inner container.

3. Articles contained in the package should be held and immobilized inside the outer structures by interior packaging to prevent movement and resultant damage from impact against the inside of the package itself.

4. The means for holding an object inside a shipping container must transmit forces to the strongest parts of the contained objects.

The author of the NRC report developed a series of research reports which further supported the need for improvements in general aviation aircraft crashworthiness (2-11).

Since the 1944 NRC report, other researchers have provided numerous publications which show that the survivability of general aviation aircraft crashed could be greatly increased through improved occupant "packaging" techniques. It has been shown that a properly restrained occupant is capable of withstanding 20 g longitudinally and remaining nearly injury-free when the habitable area of the aircraft remains essentially intact and the impact forces are distributed over a large area of the body. Through use of additional restraint, an aircraft occupant can survive 40 g with injury. Reductions in crash impact forces transmitted to the occupant can be accomplished by use of restraining systems, energy-absorbing seats and interiors, and through the recessing of knobs, handles, levers, and other injury- producing objects.

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1 This section is extracted from NTSB SR-80-2, The Status of General Aviation Aircraft Crashworthiness, December 17, 1980.

An early research effort to improve the crashworthiness of agricultural aircraft was the 1952 demonstration of a prototype aerial applicator (cropduster) that incorporated a 50-g seat, an integral double upper torso-restraint with inertial reel, a 40-g cockpit box, a storage hopper between the engine and the pilot compartment to provide an energy-absorbing structure, and an overturn structure (10). This prototype design incorporated the basic packaging principles advocated in the 1944 NRC report and was the forerunner of modern agricultural aircraft. A study of one generation of the new agricultural aircraft for the 10-year period ending 1973 showed that these aircraft experienced 368 accidents with only 3 percent of the occupants receiving fatal injuries (12). In contrast for the same period, the fatality rate in all U.S. general aviation aircraft averaged 12.8 percent.

A 1953 report (13) described full-scale light-airplane crashes which simulated stall/spin accidents to determine occupant decelerations and the resulting forces on safety belts. This early research effort used anthropomorphic dummies, accelerometers, and tensiometers to measure accelerations along the longitudinal, vertical, and lateral axes for three impact speeds — 42, 47 and 60 mph. Also, the crash impacts were recorded on motion-picture film. Tests were conducted with the front-seat dummy restrained by a seatbelt alone and with the rear-seat dummy restrained by a seatbelt/shoulder harness system or by a seatbelt alone.

Damage to dummies restrained by a seatbelt alone confirmed earlier accident study findings about the causes and types of injuries. Through study of filmed crash sequences and recorded acceleration and force measurements, researchers were able to define the movements of and the forces upon the dummies for specified restraint conditions at deceleration rates achieved during the tests. Also, data obtained from these tests provided improved understanding about the distribution of deceleration loads during crashes. The detailed descriptions reported about the movements of and damage to dummies demonstrated that it is not possible to protect front-seat occupants in moderate crashes through the use of seatbelts alone. However, the tests showed that stall/spin simulated impact speeds up to 60 mph (the maximum speed used in these tests) were survivable when occupants were restrained by a seatbelt/shoulder harness system.

The FAA has published numerous reports applicable to general aviation crashworthiness. An April 1966 report concluded that simple attenuators for reduction of head injuries in light-aircraft crashes "could be installed on present aircraft with meager weight and cost penalty and would save hundreds of lives in survivable crashes." (14). In September 1966, another report (15) stated:

1. There is a critcial need to improve restraint systems in general aviation aircraft and to promote their use. This need is indicated by the significant increases in serious and fatal injuries being sustained in potentially survivable accidents.

2. One of the many directly contributing factors to these injuries is the use of inadequate or incomplete restraint equipment. It is clearly demonstrated that the current practice of using only a seatbelt to restrain vulnerable parts of the body cannot provide the necessary protection.

3. Specifically, the use of a seatbelt alone cannot provide adequate protection to a seated occupant, since the upper body components (e.g., head) are free to move during abrupt decelerations and strike surrounding structures.

This research project dynamically tested five basic general aviation aircraft models and types to evaluate the structural integrity of areas selected for restraint attachment. Each area selected was found reliable for minimum dynamic loads of 500 pounds which produced deceleration peaks in excess of 20 g with onset rates of 47 to 49 feet per second and an event duration of 0.33 second. The study concluded that for each aircraft tested, only small upholstery modifications were necessary to permit proper atachment installations for upper torso restraint belts.

A July 1971 FAA report (16) provided general information "to assist the general aviation airplane designer in developing improved structural crashworthienss designs." While little new information was presented in this report, it did provide a programmatic approach to achieving improved crashworthiness and presented improved analysis techniques. This report was followed in February 1973 by another FAA report that reaffirmed the FAA's informal, non-regulatory efforts to encourage general aviation crashworthiness improvements (17).

In August 1972, the FAA initiated a research program for the development of a three-dimensional mathematical model of a light- aircraft seat, occupant, and restraint system. This model was developed to form the basis for a simulation computer program specifically for use in crashworthy design and analysis of light- aircraft seats and restraint systems. A user-oriented computer program, "Seat Occupant Model-Light Aircraft (SOM-LA)," was developed based upon the three-dimensional model to aid in the design and analysis of general aviation aircraft seats and restraint systems. Reports issued about this project in 1975 and 1979 (18, 19) indicate that the computer program is capable of predicting, for any given set of crash conditions, the response of the seat and occupant, restraint system loads, and various injury criteria.

The February 1973 report (20) stated: "The primary technological efforts must continue to be devoted to reduce the number of crashes by improving pilot performance and airworthiness." Despite a lack of emphasis on crashworthiness design considerations, the report effectively described and documented the need for improvements in general aviation aircraft crashworthiness and provided current information to assist an aircraft design engineer in developing "his own acceptable means" for complying with FAA airworthiness standards and "as a contribution to the overall effort" toward increasing safety in small airplanes. Crashworthiness considerations suggested as important to the designer included:

1. Seat orientation - since experimental studies have shown that human tolerance is dependent on the contact area and the load direction with respect to the body.

2. Seat parameters - since the inertial loads imposed on a seat in a crash situation are generated by the effective weight of the occupant plus the weight of the seat. Also, the loads imposed upon the seat by the occupant can vary depending on whether the restraint system is anchored to the seat or to the airframe.

3. Seat design requirements due to occupant velocity relative to cabin floor velocity under impact conditions - since the maximum relative velocity can create deceleration factors of 1.2 to 2 times that of the floor deceleration.

4. Seatbelt anchors and buckles - since these are the common points of failure.

5. Occupant upper torso restraint systems - since seatbelts alone do not provide the degree of body support to prevent fatal head and upper torso injuries. (Considerable information is provided on shoulder harness and inertial reel design considerations).

6. Control column and wheel designs - since these items are in the head and torso flailing area and can cause serious injury to an occupant thrown against them.

7. Control design - since padding, recessing, and yielding designs can minimize puncture hazards.

8. Protective padding of items in the occupant flailing area - since restraint systems cannot prevent flailing of the extremeties.

9. Anchoring of cabin equipment - since loose items or fixed equipment can become lethal missiles upon crash impact.

Another FAA report, published in August 1973, compared the levels of crash protection provided by seatbelt-alone, seatbelt/shoulder harness, and seatbelt/air bag occupant restraint systems for general aviation aircraft (21). Tests showed that the seatbelt/ shoulder harness and the seatbelt/air bag systems compared favorably and decreased the acceleration for the head area by a factor of 3 and for the chest areas by 1½ times the acceleration experienced with a seatbelt-alone occupant restraint system. The seatbelt/air bag system was found to be most effective in preventing the flailing of upper extremities. However, the potential for this system to cause a hazard through inadvertent actuation and the problem of developing a reliable crash actuator made the seatbelt/shoulder harness system most desirable.

In August 1978, the FAA issued an initial project report which evaluated the potential for reducing crash injuries through improved seat design (22). This report pointed out that there is no standard specified in 14 CFR 23 for absorbing downward inertial forces generated during crash conditions in airplanes that do not have retractable landing gear. The report went on to conclude that to meet the minimum maneuver load factors of 14 CFR 23.337, the downward load factor for seats would have to be 3.8 g for normal category, 4.4 g for utility category, and 6.0 g for aerobatic category airplanes. FAA seat standards are established in 14 CFR 37, Technical Standard Order Authorization, which adopts Technical Service Order C39a (TSO-C39a), and this TSO, in turn, adopts National Aircraft Standard 809 (NAS-809). NAS Standard 809 established static directional seat strength requirements for normal and utility aircraft seats as: forward, 9.0 g; sideward, 3.0 g; upward, 3.0 g; and downward, 7.0 g. However, the TSO provides that the manufacturer need not exceed the requirements of the applicable regulations; thus, the sideward design force requirement of NAS-809 is reduced by 50 percent and the downward design force requirements are eliminated.

The 1978 FAA report included the results of a survey of six small airplane manufacturers' seat data and reported the range of ultimate static seat capabilities to be:

Load Direction	Range of Test Load Findings (g)
Forward	7.9-12.7
Sideward	1.8-04.2
Downward	6.1-10.6
Upward	2.6-04.5

From these data, it was estimated that a 17-percent improvement in survivability could be realized without changing the forward design factor if 14 CFR 23 required that seat design load factors be increased to: sideward, 3.0 g; downward, 7.5 g; and upward, 5.5 g. Deficiencies in current seat criteria listed in this report were:

1. The basic minimum design strength for seats is designated in terms of a static load factor, in that the occupant is to be protected when he experiences the designated inertial forces, regardless of the acceleration level imposed on the occupant/ seat/restraint system by the attaching airframe. However, current data indicate that peak airplane accelerations can be expected to produce inertial loads which exceed current seat strength requirements. When safety belts are anchored to the seats, seat reaction loads, as indicated by a May 1969 FAA/NAFEC (National Aviation Facilities Experimental Center)* study (23) are significantly greater than a simple occupant weight times the airplane acceleration, and reduce the protection afforded occupants.

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* NAFEC is now designated the FAA Technical Center.

2. The assumption that occupant/seat/restraint systems are rigid masses is not valid and to realize a more rational level of safety, seat criteria are needed which recognize the effects of dynamic loading.

The report made a convincing argument for developing new seat standards and testing requirements. Criteria for new standards and justifications for the proposed changes were included.

Ensuing research reports issued (24, 25-35) have been issued by the FAA and the National Aeronautics and Space Administration (NASA) about the findings and analysis of a joint general aviation crash test program (KRASH). This program, initiated jointly by the FAA and NASA in 1973, included a series of crash tests to obtain information on single- and twin-engine airplanes under controlled free-flight conditions and had as its objectives (1) to derive an understanding of what happens to the structure of an airplane subjected to crash loads, and (2) to learn how varous impact parameters affect the magnitude and pattern of the structural damage. The justification used for conducting the tests was to obtain essential information for predicting structural collapse and for designing new concepts for seat, occupant restraint systems, and cabin interiors. The program designers recognized that this effort was similar to the National Advisory Committee for Aeronautics crash test program conducted in the early 1950's (13), but believed that additional testing was justified to obtain data representative of current general aviation airplanes. Project KRASH developed a computerized method for analyzing general aviation aircraft under probable accident conditions. This analytical tool is intended to assist aircraft designers in the development of improved crashworthiness and presently is being used experimentally by at least one major aircraft manufacturer.

Project KRASH developed a computerized method based upon spring damper methodology whereby a seat/occupant model would consist of masses joined by beams representing the seat and occupant which could be excited by pulses of varying shape, magnitude and duration. This analytical tool is intended to assist aircraft designers in the development of improved crashworthiness and in 1980 was being used by at least one major aircraft manufacturer. In fact, as will be demonstrated later in the description of the post 1980 R&D, the KRASH methodology has proven to be an invaluable tool for dynamic analysis.

7.2 1980 - Present

The FAA established a Crash Dynamics Engineering and Development Program in the early 1980's as a long-term effort to research the analytical methods needed for estimating the response of human/seat restraint systems in a "survivable" impact, and to establish seat and occupant restraint system design standards. However, the program was not publicized until September 21, 1984 when the Federal Register Volume 49, No. 185 outlined the details in a "Preview of the Agency's Crash Dynamics Program" along with a Draft Advisory Circular on "Human Exposure To Impact".

Figure 7-1 illustrates the general approach to the systems analysis in which the crash event itself is directly related to the airframe/occupant response and an established performance criteria. Crash scenario studies were initiated to determine the relationship of impact injuries.

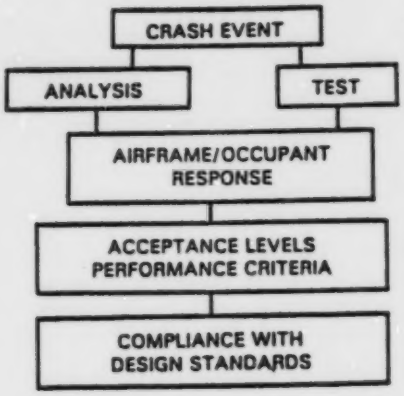

Figure 7-1. FAA General Aviation Crash Dynamics Program

The Draft Advisory Circular on Human Exposure to Impact provided reasonable estimates of impact injury criteria for humans. It dealt with the system elements for occupant protection and stressed their interaction to provide energy absorption and distribution of load over the body. Description of injuries to the chest, legs, spine and head in various duration accelerations are provided and related to restraint effectiveness with comments on the hazards of incorrect design and usage. The references for Accepted Injury Criteria are all from the Federal Motor Vehicle Safety Standards.

Airframe/occupant response became the focus of the development of analytical methods and the intention to correlate them with integrated full-scale impact tests. The digital computer offered a new opportunity to utilize high speed computing methodology to quantitatively evaluate a crash event in terms of the mechanics of the crash event, the aircraft structure/furnishings and occupants.

Ultimately, the program was expected to enable assessment of the aircraft/occupant system in the early design stages of an aircraft by providing the capability of directly relating the crash event to an occupant's response to that event and to respective acceptance/ performance criteria.

The FAA analytical goals provided an opportunity to utilize the SOM-LA computer program which it had initiated in 1972 as a design tool for small aircraft seats. The program was completed in March 1983 as a user-oriented tool and is available from the NTIS under Catalogue DOT/FAA/CT-62-33-1.

Another FAA initiative in consort with NASA sponsored the program DYCAST developed by Grumman Aerospace Corporation to obtain aircraft response to a crash event. The contract, NASI 13148 was dated April 1982 and completed in 1984 and is available from Cosmic, University of Georgia. DYCAST is a nonlinear finite-element computer program which can dynamically test aircraft fuselage sections and indicate deflection/failure of the fuselage understructure and floor accelerations as well as the curved structure failures modes.

7.2.1 General Aviation Safety Panel 1982

In 1982 the FAA Administrator requested the consensus of a broad constituency of the general aviation community regarding actions by which the FAA could postively influence general aviation safety. A General Aviation Safety Panel, GASP consisting of representatives of manufacturers, operators, consumers, insurers, and the aviation press met during 1982 and submitted a report in February 1983 with recommendations concerning weather, training, safety information publication, and crashworthiness. The FAA requested the GASP to form a working group of aviation specialists and scientists to develop specific recommendations to improve crashworthiness.

This committee, known as the General Aviation Safety Panel (GASP) met several times on a voluntary basis and responded in May 1984 with a proposal for enhanced crash tolerance for Part 23 general aviation aircraft applying for initial type certification after December 31, 1985 for operations with fewer than ten passenger seats. This represented the GASP response to Notice No. CE-83-1, Docket No. 23494, entitled "Small Airplane Airworthiness Review Program" published in the Federal Register on January 31, 1983.

GASP was instrumental in attempting to develop a practical, realistic test procedure for seats and restraint systems as a means for evaluating the provisions for crash injury in small aircraft. Representatives of the NTSB, NASA Langley Research Center, GAMA, U.S. Army, FAA and industry witnessed test procedures at the FAA Civil Aeromedical Institute (CAMI). Each representative brought to the deliberations extensive research experience into improving crash injury protection. In fact, it was agreed that the U.S. Army Crash Survival Design Guide, USARTL-TR-74-22 prepared by Simula Inc. would serve as a starting point for the tests. As well, NTSB crash investigation of data from controlled small airplane crashes conducted at NASA Langley Research Center, and correlated to studies and computer modelling done by Simula Inc. contributed to the test criteria.

The results of the GASP/CAMI efforts are documented in report 850851 "Data for the Development of Criteria for General Aviation Seat and Restraint System Performance" presented at the SAE 1985 Meeting on Crash Dynamics of General Aviation Aircraft by Richard Chandler of FAA/CAMI. The conclusion of the report 850851 states: "The recommendations of the GASP were formally presented to the Federal Aviation Administration as part of the Regulatory Review Program for Part 23 of the Federal Aviation Regulations. Like all documents submitted in that review, they are being considered for possible

implementation in the Regulations. In the interim, these recommendations, as a consensus of knowledgeable specialists regarding appropriate performance goals for seat and restraint systems for small aircraft, should be useful to designers of those systems. This has been demonstrated in CAMI tests, where two modified seats have passed the tests, and new prototype crew and passenger seats have successfully achieved the goals outlined in the recommendations."

The NTSB contribution to the understanding of crash impact severity and related data was published in three volumes comencing with the report in 1983 entitled "Safety Report: General Aviation Crashworthiness Project - Phase I". The Phase II report, March 1985 dealt with impact severity and potential injury prevention, and the Phase III report, September 1985 provided data on acceleration loads and velocity changes of survivable general aviation accidents. The contents of these volumes have been covered in detail in Sections 5.3.2, 5.3.3 and 5.3.4 of this report.

Acceptance level and performance criteria which relate the occupant's response to a crash event were judged by the FAA to be required to assess impact characteristics of an aircraft/ occupant protection system. Accordingly the Draft Advisory Circular published in Federal Register Volume 49, No. 185, September 21, 1984 was issued as Advisory Circular No. 21-22, June 20, 1985 to provide guidance in the evaluation of occupant survivability characteristics. The goal stressed the systems considerations whereby the human occupant is only one element while the aircraft design should absorb impact energy, help to control the impact environment, maintain adequate living space, provide egress pathways for rapid evacuation, and use fire resistant systems to provide adequate time for egress. Thus, an impact injury protection system should reduce the level of injury insofar as possible from fatal, to serious, to minor, to none.

7.2.2 Post Crash Fire Research

The FAA recognition of the need to provide adequate time for egress from a crashed aircraft led to a parallel engineering and development program related to post impact fires. The research into fire safety had been underway for several years and consultation with industry resulted in the formation of the Special Aviation Fire and Explosion Reduction Advisory Committee, SAFER. Membership included representatives from government and the aviation community. Its role was "to examine the factors affecting the ability of the cabin occupant to survive in the post crash environment and the range of solutions available". However, the SAFER appears to have addressed only transport category aircraft because no reference was found to its recommendations for general aviation aircraft.

FAA's research into fuel containment for small aircraft has shown that "..... crash-resistant fuel cells used with self-sealing frangible fuel line couplings can effectively reduce post crash fires in general aviation aircraf ....". Furthermore, the research has shown that the safety advantages of crash resistant fuel systems outweigh the penalties of weight and volume. Finally, the research has shown that impact resistant tanks "could provide useful benefits at moderate costs.

The NTSB Special Study AAS-80-2 into General Aviation Accidents: "Postcrash Fires and How to Prevent or Control Them" is notable principally for its conclusions and recommendations which are as follows:

Conclusions - Post Crash Fire

1. Postcrash fire is a serious problem in general aviation accidents, and escape time from small aircraft is extemely limited.

2. Control of ignition sources and fuel modification techniques would enhance the fire safety of the aircraft, but they will not eliminate the potential for fire and are not feasible for use in general aviation aircraft based on the current state-of-the-art.

3. Research into the postcrash fire problem has illustrated that containment of fuel is the most promising avenue for prevention of fires and is both feasible and achievable now.

4. The regulations under which many aircraft were designed and certificated, and are still being manufactured, do not address fuel containment in crash conditions.

5. Existing regulations are not adequate to provide the minimum standards necessary to improve crash/fire survivability of newly certificated aircraft.

6. Previously expressed reasons against using crash-resistant fuel systems—cost, weight, and state-of-the-art--are no longer valid.

Recommendations - Post Crash Fire

As a result of its special study, the National Transportation Safety Board has recommended that the Federal Aviation Administration:

"Amend the airworthiness regulations to incorporate the latest technology for flexible, crash-resistant fuel lines, and self-sealing frangible fuel line couplings at least equivalent in performance to those used in recent FAA tests and described in Report No. FAA-RD-78-28 for all newly certificated general aviation aircraft." (Class II, Priority Action) (A-80-90)

"Amend the airworthiness regulations to incorporate the latest technology for light weight, flexible crash-resistant fuel cells at least equivalent in performance to those used in recent FAA tests and described in Report No. FAA-RD-78-28 for newly certificated general aviation aircraft having nonintegral fuel tank designs." (Class II, Priority Action) (A-80-91)

"Require after a specified date that all newly manufactured general aviation aircraft comply with the amended airworthiness regulations regarding fuel system crashworthiness." (Class II, Priority Action) (A-80-92).

"Fund research and development to develop the technology and promulgate standards for crash-resistant fuel systems for aircraft having integral fuel tank designs equivalent to the standards for those aircraft having nonintegral fuel tank designs." (Class II, Priority Action) (A-80-93).

"Assess the feasibility of requiring the installation of selected crash resistant fuel system components, made available in kit form from manufacturers, in existing aircraft on a retrofit basis and promulgate appropriate regulations." (Class II, Priority Action) (A-80-94).

"Continue to fund research and development to advance the state-of-the-art with the view toward developing other means to reduce the incidence of postcrash fire in general aviation aircraft." (Class II, Priority Action) (A-80-95).

Additional research by the NTSB into fuel safety concentrated on the identity of spilled fuel sources and fire related fatalities in survivable general aviation accidents. The work was undertaken at the request of the GASP and included a review of airplane accidents known to have involved spilled fuel that occurred during 1984 and 1985. In all, 149 survivable accidents involved spilled fuel of which thirty-two percent included postcrash fires, eleven percent had fire-related fatalities, eighty-four percent spilled fuel from wings, twenty-six percent from the engine, and twenty-two percent from the firewall. Most tanks were metal or wetcell, with some bladder/wetcell. Table 7-1 illustrates the comparison of spilled fuel sources in the review.

Table 7-1. Spilled Fuel Source Comparison For All Accidents In The Review

Spilled Fuel Sources	Number Of Spills	Number Of Postcrash Fires	Number Of Airplanes Destroyed Regardless of Fire	Number Of Fire-Related Fatalitie-
Engine	6	1	2	0 (0)
Fuselage	4	2	4	0 (0)
Wing Tank	72	23	44	5 (31)
Firewall	1	0	1	0 (0)
Wing & Fuselage	10	1	7	0 (0)
Wing & Engine	14	6	12	5 (31)
Wing & Firewall	14	4	12	3 (19)
Wing, Engine & Firewall	14	7	13	3 (19)
Engine & Firewall	2	1	1	0 (0)
Fuselage & Firewall	3	0	0	0 (0)
Wing, Engine, Firewall, Fuse	2	1	2	0 (0)
Wing, Firewall & Fuselage	3	1	1	0 (0)
Wing, Engine & Fuselage	4	1	0	0 (0)

() Percent of accidents with fire-related fatalities.

The conclusions of the review clearly indicated a major source to be fuel tanks in the wings, while engines and firewall areas are potentially significant because of their frequency of failures and proximity to potential ignition sources. The recommendations stressed the most beneficial improvement in fire crashworthiness would appear to result from the installation of crash-resistant fuel cells with spill-proof fittings. Crash-resistant fuel pumps, carburetors, fuel lines and drains would reduce the incident of spilled fuel near ignition sources.

In March 1985 the FAA anounced its intention to incorporate airworthiness standards for crash-resistant fuel systems into Part 23 by an ANPRM 85-7 Docket 24494. Recommendations A-80-90 through 95 of the NTSB were acknowledged along with the FAA Technical Center full scale crash tests, and U.S. Army experience with crash-resistant fuel systems, as providing information and data appropriate for applicable design conditions and criteria. However, the FAA anticipated that additional technical and economic data were necessary and requested comments relevant to the recommendations acknowledged in the ANPRM. It further indicated that the rulemaking would probably deal with three specific components, namely: flexible crash-resistant fuel lines; self-sealing frangible fuel line couplings; and lightweight flexible crash-resistant fuel cells.

An NPRM 85-11 Docket 23815 was published in the Federal Register Volume 50, No. 87 on May 6, 1985 with a proposal to amend Parts 23 and 91 to require the installation of shoulder harnesses at all seats of normal, utility, and acrobatic category aeroplanes with a passenger seating configuration, excluding pilot seats, of nine or less, manufactured one year after the effective data of the proposed amendment, and to require the pilot-in-command to brief passengers on how to fasten and unfasten their shoulder harness for take-off and landing if shoulder harnesses are installed. Parts 23 and 91 were amended December 12, 1985 in accordance with the draft amendments of the NPRM.

The roles of government, industry, and aviation associations during the early 1980's have been interwoven both by intent and by the desire of some organizations to urge the government to make-progress more rapidly in developing crashworthiness legislation. The FAA and NASA have jointly and severly contracted research to industry and universities which produced the KRASH, DYCAST, SOM-LA computer programs, dynamic test techniques, design standards, and acceptance/performance criteria to assess impact characteristics of aircraft/occupant protection. Simula, Arizona State University, Wayne State University, University of Michigan, and the U.S. Army Research and Technology Laboratories (AVRADCOM) were among the key researchers whose work has contributed to crashworthiness research and development. The Society of Automotive Engineers (SAE) has held a meeting on aviation crash dynamics each year since 1981 at which papers from the various researchers have been presented and discussed. These papers and their attached lists of references plus papers available from the U.S. National Technical Information Service provide a comprehensive inventory of the research and development in the 1980's. Volume II contains an up-to-date list of references compiled from all the foregoing sources.

On December 12, 1986 the Federal Register Volume 15, No. 239 published FAA proposed rules under an NPRM to Part 23 (Docket No. 24147 Notice 86-19) on Small Airplane Airworthiness Review Program Notice No. 1. This notice is the first* of a series resulting from the recent review of Part 23 discussed at the Small Airplane Airworthiness Review Conference held October 22-26 1984. In summary the proposed amendments would introduce: dynamic loading on the occupant, seat, and surrounding structure; emergency landing conditions to protect occupants; provision to safe-guard against doors opening in flight or jamming after minor accident; provision for single point release for belt and harness up to 215 pound occupant; greater loads for cargo restraint when cargo is located aft of occupants; and require additional emergency exists on the side opposite to the entrance door.

The proposed amendments are clearly similar to the recommendations of the GASP and when adopted will achieve a large measure of the rule changes which had been sought for many years. The earliest likely date of adoption would be one year after the June 87 response date stated in the NPRM, but the FAA could move more rapidly if the comments are supportive.

7.2.3 Summary

From the vast amount of reference material reviewed and interviews conducted the following general conclusions can be summarized with respect to small aircraft crashworthiness R&D in the United States.

1. Many U.S. government agencies have been involved in general aviation crashworthiness R&D. The major ones are the NTSB, FAA, NASA, U.S. Army and CAMI.

2. The principal areas of focus in general aviation crashworthiness R&D have been:

   - seats
   - harness/restraint systems
   - post crash fire
   - human survival
   - crash dynamics - impact - pulse
   - structural design for crash impluse

3. In addition to performing internal R&D, U.S. government agencies have funded and made extensive use of institutional and private sector (contract) support. A key feature of R&D in this area has been the close working relationships of government agencies and universities.

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* The reference to "First of a Series" does not mean that the remaining notices will deal with crashworthiness. They will deal with other review program topics such as powerplants, systems, flight, reliability, etc.

4. Accident investigative analysis and data collection procedures have been well established and have been incorporated into on going activities.

5. R&D efforts in the area of general aviation crashworthiness do not appear to have been successfully coordinated. Many of the researchers interviewed felt that a systems approach similar to that taken for Transport category would be highly desireable.

6. The role of the U.S. Army and Bell Helicopters R&D with rotary aircraft crashworthiness has been extremely valuable in developing/assessing new crashworthiness standards - including those for new materials.

7. Legislative progress (regulation) has been limited in comparison to R&D efforts. Some of the major reasons for this include:

   - industry and private interests have developed solutions but no data is available due to confidentiality; and

   - potential threat of litigation prevents knowledge from being shared.

8. A wide variety of special interest and lobby groups - AOPA, SAE, Flight Safety Foundation, GAMA, numerous private research companies, etc. have contributed to pressing the government to address and incorporate small aircraft crashworthiness R&D into legislation.

9. R&D in general aviation crashworthiness in the United States has focussed almost exclusively on new aircraft production. Retrofit has not been addressed.

BIBLIOGRAPHY - U.S. R&D ACTIVITIES

1. H. DeHaven, "The Relationship of Injuries to Structure in Survivable Aircraft Accidents", National Research Council, Committee on Aviation Medicine, Report No. 440, July 9, 1945.

2. H. DeHaven, "Crash Research from the Point of View of Cabin Design", Aeronautical Engineering Review, Volume 5, Number 6, June 1946.

3. H. DeHaven, "Crash Deceleration, Crash Energy, and Their Relationship to Crash Injury", Air Force Material Command, Dayton, Ohio, AF Technical Report No. 6242, December 1950.

4. H. DeHaven, and A. H. Hasbrook, "Shoulder Harness: It Use and Effectiveness," Aviation Crash Injury Research of Cornell University, New York, Rept. 32-0-38, February 1951 (Reprinted May 1956).

5. H. DeHaven, "Accident Survival-Airplane and Passenger Automobile," Symposium on "Packaging the Passenger", Society of Automotive Engineers, New York, January 1952.

6. H. DeHaven, "Packaging the Passenger", Society of Automotive Engineers Journal, 60:55-56, June 1952.

7. H. DeHaven, "The Site, Frequency, and Dangerousness of Injury Sustained by 800 Survivors of Light Plane Accidents", Department of Public Health and Preventive Medicine, Cornell University Medical College, New York, July 1952.

8. H. DeHaven, "Develop of Crash-Survival Design in Personal, Executive and Agricultural Aircraft", Crash Injury Research, Cornell University Medical College, New York, May 1953.

9. H. DeHaven, B. Tourin, and S. Macri, "Aircraft Safety Belts: Their Injury Effect on the Human Body", Crash Injury Research, Cornell University Medical College, New York, July 1953.

10. H. DeHaven, "Development of Crash-Survival Design in Personal, Executive and Agricultural Aircraft", Crash Injury Research, Cornell University Medical College, New York, May 1953.

11. H. DeHaven, "Beginnings of Crash Injury Research", Proceedings of Thirteenth Stapp Car Crash Conference, Society of Automotive Engineers, Inc., New York, 1969, pp. 422-428.

12. G.J. Walhout, "Crashworthiness Observations in General Aviation Accident Investigations - A Statistical Overview", in "Aircraft lCrashworthiness", Charlottesville, Virginia: The University of Virginia Press, 1975.

13. A.M. Eiband, S.H. Simpkinson, and D.O. Black, "Accelerations and Passenger Harness Loads Measured in Full-Scale Light-Airplane Crashes", National Advisory Committee for Aeronautics, Technical Note 2991, 1953.

14. J.J. Swearingen, "Injury Potentials of Light-Airplane Instrument Panels", Civil Aeromedical Institute, Report No. 66-13, 1966.

15. J.W. Young, "Recommendations for Shoulder Restraint Installation in General Aviation Aircraft," Civil Aeromedical Institute, Report No. 66-33, 1966.

16. Federal Aviation Administration, "Crashworthiness Design Handbook", Airframe Section, Engineering and Manufacturing Branch, Flight Standards Technical Division, Oklahoma City, Oklahoma, July 1971.

17. A.L. Pennybaker, J.W. Ross, and G.L. Wilson, "A Summary of Crashworthiness Information for Small Airplanes", Flight Standards Services Technical Report FS-70-592-120A, February 1973.

18. Department of Transportation/Federal Aviation Administration, "Development of a Scientific Basis for Analysis of Aircraft Seating Systems", Report No. FAA-RD-74-130, January 1975.

19. Department of Transportation/Federal Aviation Administration, "Evaluation of Seating and Restraint Systems Conducted During Fiscal Year 1978", Report No. FAA-AM-79-17, June 1979.

20. A.L. Pennybaker, J.W. Ross, and G.L. Wilson, "A Summary of Crashworthiness Information for Small Airplanes", Flight Standards Services Technical Report FS-70-592-120A, February 1973.

21. J. Sommers, "A Comparison of General Aviation Occupant Restraint Systems", Systems Research and Development Service, Report No. FAA-RD-73-114, 1973.

22. J.W. Ross, Jr., "Initial Project Report: Energy Absorbing Seat Designs", Project No. 70-599-120A, Federal Aviation Administration, August 1978.

23. D.W. Voyles, /Dynamic Test Criteria for Aircraft Seats", Aircraft Development Service, National Aviation Facilities Experimental Center, Atlantic City, New Jersey, FAA Report No. NA-69-5, May 1969.

24. Department of Transport/Federal Aviation Administration, "A Method of Analysis of General Aviation Airplane Structural Crashworthiness", Report No. FAA-RD-76-123, September 1976.

25. Department of Transportation/Federal Aviation Administration, "Full Scale Crash Test Experimental Verification of a Method of Analysis for General Aviation Airplane Structural Crashworthiness", Report No. FAA-RD-77-189.

26. Department of Transportation/Federal Aviation Administration, "General Aviation Airplane Structural Crashworthiness Users Manual, Volume I, Program "KRASH" Theory", Report No. FAA-RD-189, February 1978.

27. Department of Transportation/Federal Aviation Administration, "General Aviation Airplane Structural Crashworthiness User's Manual, Volume II, Input-Output, Techniques and Applications," Report No. FAA-RD-77-189-11, February 1978.

28. Department of Transportation/Federal Aviation Administration, "General Aviation Airplane Structural Crashworthiness User's Manual, Volume III, Related Design Information", Report No. FAA-RD-77-189-111, February 1978.

29. Department of Transportation/Federal Aviation Administration, "Evaluation of Seating and Restraints Systems and Anthropomorphic Dummies Conducted During Fiscal Year 1976", Report No. FAA-AM-78-6, February 1978.

30. J.W. Ross, Jr., "Initial Project Report: Energy Absorbing Seat Design", Project No. 70-599-120A, Federal Aviation Administration, August 1978.

31. Department of Transportation/Federal Aviation Administration, "General Aviation Airplane Structural Crashworthiness Programmer's Manuals", Report No. FAA-RD-78-120, December 1978.

32. Department of Transportation/Federal Aviation Administration, "Development, Experimental Verification and Application, Program "KRASH" for General Aviation Airplane Structural Crash Dynamics", Report No. FAA-RD-77-119, December 1978.

33. Department of Transporation/Federal Aviation Administration, "General Aviation Airplane Structural Crashworthiness Programmer's Manual", Report No. FAA-RD-78-120 (Revised), June 1979.

34. Department of Transportation/Federal Aviation Administration, "Evaluation of Seating and Restraint Systems Conducted During Fiscal Year 1978", Report No. FAA-AM-79-17, June 1979.

35. Department of Transportation/Federal Aviation Administration, "General Aviation Airplane Structural Crashworthiness User's Manual, Volume II, Input-Output, Techniques and Applications", Report No. FAA-RD-77-189 (Revised), September 1979.

8. CRASHWORTHINESS RESEARCH ACTIVITIES - CANADA

8.1 Introduction

Following a comprehensive search of the technical data bases available, Canadian departments of government, industry and universities were contacted to ascertain what if any R&D in small aircraft crashworthiness had been carried out, was ongoing or was planned.

8.2 Government

The following government departments/agencies were contacted and interviews carried out:

Transport Canada
Transportation Development Centre
Canadian Aviation Safety Board
National Defence
National Research Council
National Aeronautical Establishment
Defence and Civil Institute of Environmental Medicine

No departments or agencies had ongoing R&D in the area of small aircraft crashworthiness. The National Research Council had developed a small program several years ago but funding was not forthcoming. No agencies with the exception of CASB are currently considering doing any work in this area.

Most of the senior managers interviewed expressed interest in the subject and were aware of the recommendations of the Commission of Inquiry into Aviation Safety regarding small aircraft airworthiness. However, all acknowledged that government spending cuts had affected most programs and were not optimistic in obtaining support for new initiatives. Of the few areas under consideration were R&D in composite materials (by the NRC) and retrofit R&D aimed at improving safety of small aircraft was a concern of Transport Canada and CASB.

All aviation agency managers acknowledged the absence of a clearly defined "home" or lead agency for crashworthiness R&D and admitted that any R&D in this field would likely be handled as an add - on item to ongoing R&D which they were engaged in.

8.3 Industry

The companies that were contacted are listed as follows:

DeHavilland Aircraft Co.
Canadair
Pratt and Whitney

Field Aviation
Innotech Aviation
IMP

The companies contacted have not at any time carried out R&D with respect to civil crashworthiness requirements. They all stated that they could not imagine any work being carried out unless it was financed, in whole or in part by the government.

8.4 Universities

The only university in Canada that has carried out R&D in small aircraft crashworthiness is the Institute for Aerospace Studies at the University of Toronto. For approximately ten years the Institute has been involved in the physical testing of model fuselage structures and coordination of results with computer programs. Some of these activities have been funded by NASA and U.S. DOD grants.

Interviews with the director of the Institute confirmed that they would like to extend work into the area of composite structures. Several proposals to the Canadian government requesting funding have been denied.

8.5 Summary

From the data search and the interviews conducted it is clear that very little Canadian R&D has taken place in the past and little or no research is currently ongoing. The work in progress is comprised of work at the Institute of Aerospace Studies at the University of Toronto and several data collection studies at the CASB. At least two organizations have expressed a desire to conduct R&D in composite materials.

9. SYNTHESIS OF FINDINGS - GAPS ANALYSIS

9.1 Introduction

The extent of ongoing research and development work has slowed although it is clear when talking to the principal researchers that much remains to be done. Superficially, the volume of referenced studies suggests it would be difficult to identify gaps in small aircraft crashworthiness R&D, but under scrutiny the "gaps" begin to appear.

Six areas or "gaps" have been identified as potential subjects of focus for future R&D. These areas include: research into the applicability of existing crash dynamics data including computer simulation/modelling; systems approach/coordination; retrofit; composites; post crash survival; and fuel systems (post crash fire). They are depicted schematically in Figure 9-1 and are outlined briefly in the text that follows.

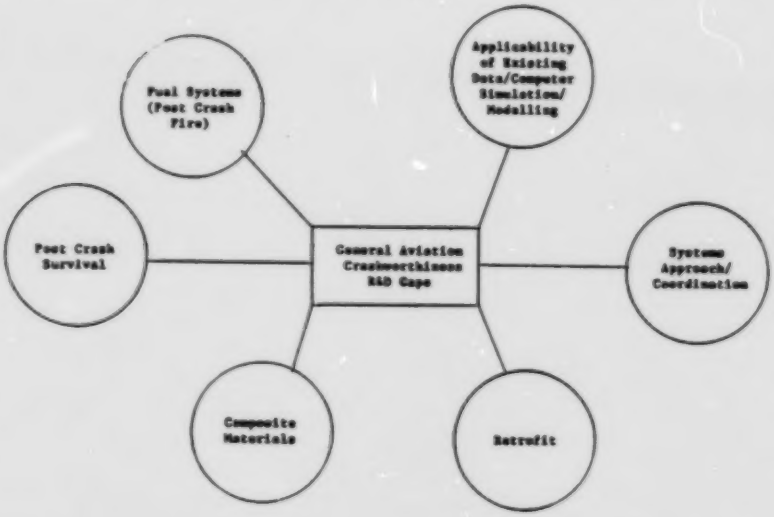

Figure 9-1. Research and Development Gaps - General Aviation Crashworthiness

9.1.1 Applicability of Crash Dynamics Data

The reliability of the application of the existing crash dynamics data during design and dynamic testing is dependent upon the realism of the crashworthiness investigative techniques used to define impact severity, injury mechanisms, structural failure modes, performance of seats and restraints, and the myriad of dynamic testing and computer modeling programs undertaken by research organizations.

The principal researchers have expressed the need for further research work to refine or expand upon their original work which entailed assumptions which are restrictive in light of interaction of elements of the crashworthiness system. As an example the NTSB has demonstrated that in survivable accidents with shoulder harnesses, the seats have withstood inertia forces much higher than 9 g because the system includes the seat, and human torso restrained by lap and shoulder harness which appears to distribute the crash impact pulse in a manner which increases the system strength by 50 to 100%.

Not all interactions are positive and to some degree many are suspected to have negative influences such as the difficulty encountered with dummies tending to slip within the restraint system, and seat blocks which behave differently with a dummy than with a human torso.

As a consequence, there is a mixture of suggestions from researchers which include more opportunities to exchange views with one another, refinement of testing techniques, continued studies of crash impact data from survivable accidents, and further enhancements to modelling techniques.

To a degree the NPRM 86/19 recognizes the applicable shortcomings of the crash dynamics data use for design and therefore requires proof by dynamic testing. However, it is the feeling of some researchers that designers may be tempted to take latitude with test techniques because of the lack of realism which has contributed to the current simulation methodology.

Therefore, there is a consensus that further research should be focused upon the applicability of the existing crash dynamics data, dynamic test methodology and computer modelling.

9.1.2 Computer Modelling and Dynamic Testing

KRASH[1], SOM-LA[2], and DYCAST[3] computer programs originated as research tools and design aids to provide detailed analytical results of the dynamic response of the airplane and occupant. Originally the human torso response

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1 KRASH: Joint FAA/NASA general aviation crash test program on small aircraft under controlled free-flight conditions to (1) derive an understanding of what happens to the structure of an airplane subjected to crash loads and (2) learn how various impact parameters affect the magnitude and pattern of structural damage. The project KRASH developed a computerized method for analyzing general aviation aircraft under probable accident conditions. It is an analytical tool intended to assist aircraft designers. It utilizes the spring-damper approach as opposed to a finite element theory and can be effective in estimating floor pulses and their effect on the seat occupant system.

2 SOM-LA: FAA initiated research to develop a three-dimensional mathematical model of a light aircraft seat, occupant and restraint system. It formed the basis of a simulation program which is user-oriented and capable of predicting for a given set of crash conditions, the response of the seat and occupant, restraint system loads and various injury criteria. SOMLA utilizes a three-dimensional dynamic model of an occupant combined with a seat finite structural element model based upon a production general aviation aircraft seat used to develop and validate the computer program.

3 DYCAST: Joint FAA/NASA sponsored program developed by Grumman Aerospace Corporation to obtain aircraft response to a crash event. The non-linear finite-element computer program can dynamically test aircraft fuselage sections and indicate deflection/failure of the fuselage understructure and floor accelerations as well as the curved structure failure modes.

was simulated and then the model extended to spring-damper dynamic analysis of seats, floors and structure. Eventually a finite element approach for structures was developed as a research tool and evolved into a means for predicting structural responses during dynamic tests. These models are not suitable for final verification of design performance so that dynamic tests are required for proof of performance.

The dynamic testing has been undertaken principally at the FAA Civil Aviation Medical Institute (CAMI) and the FAA Technical Center. In fact, the GASP tests were conducted at CAMI. This aspect has also required extensive ingenuity in developing realistic test methodology which will simulate the actual complex nature of the seat, harness and sub-floor dynamic response which is made even more difficult by the use of dummies or test blocks to represent the human torso. A paper presented at the SAE Meeting in Witchta April 27-30, 1987 by Richard Chandler gives an excellent insight into the status of the CAMI work and he makes very clear the pitfalls which exist for designers who develop their own test facility. The situation is summarized in the conclusion of his paper as follows.

> "This paper has summarized some of the more important test procedures used at CAMI in conducting dynamic tests in accordance with the recommendations of the GASP. Since these procedures are based only on the experience at CAMI, it may be that the experience developed by other people working towards the goals of the GASP recommendations may generate a different approach. Also, several topics of interest have not been discussed in this brief paper. Details of instrumentation, analysis of data, interpretation of results, sub-tests to support the GASP recommendations, all warrant further discussion. It is hoped that the spirit of cooperative effort, which has worked so well in developing the GASP recommendations, can be continued to develop a unified approach to test procedures for use in demonstrating performance in accordance with those recommendations".

9.1.3 Systems Approach and Coordination of Research

Until the advent of the GASP there was little opportunity for the various researchers to exchange views except perhaps for the SAE periodic meetings and the FAA Small Airplane Airworthiness Review. Crashworthiness studies and research into small aircraft crash dynamics has not been pursued as cooperatively by industry, government, and universities as in the case of transport category aircraft crash dynamics and development programs. The FAA block diagram illustrating the transport aircraft approach is presented in Figure 9-2. No equivalent block diagram has been developed for general aviation aircraft. Thus, the applicability of general aviation crash dynamics data needs a joint review and by no less than the researchers who have been involved. Such a think tank is overdue in the minds of several researchers who applaud the work of the GASP, but who believe another forum or mechanism would be worth exploring.

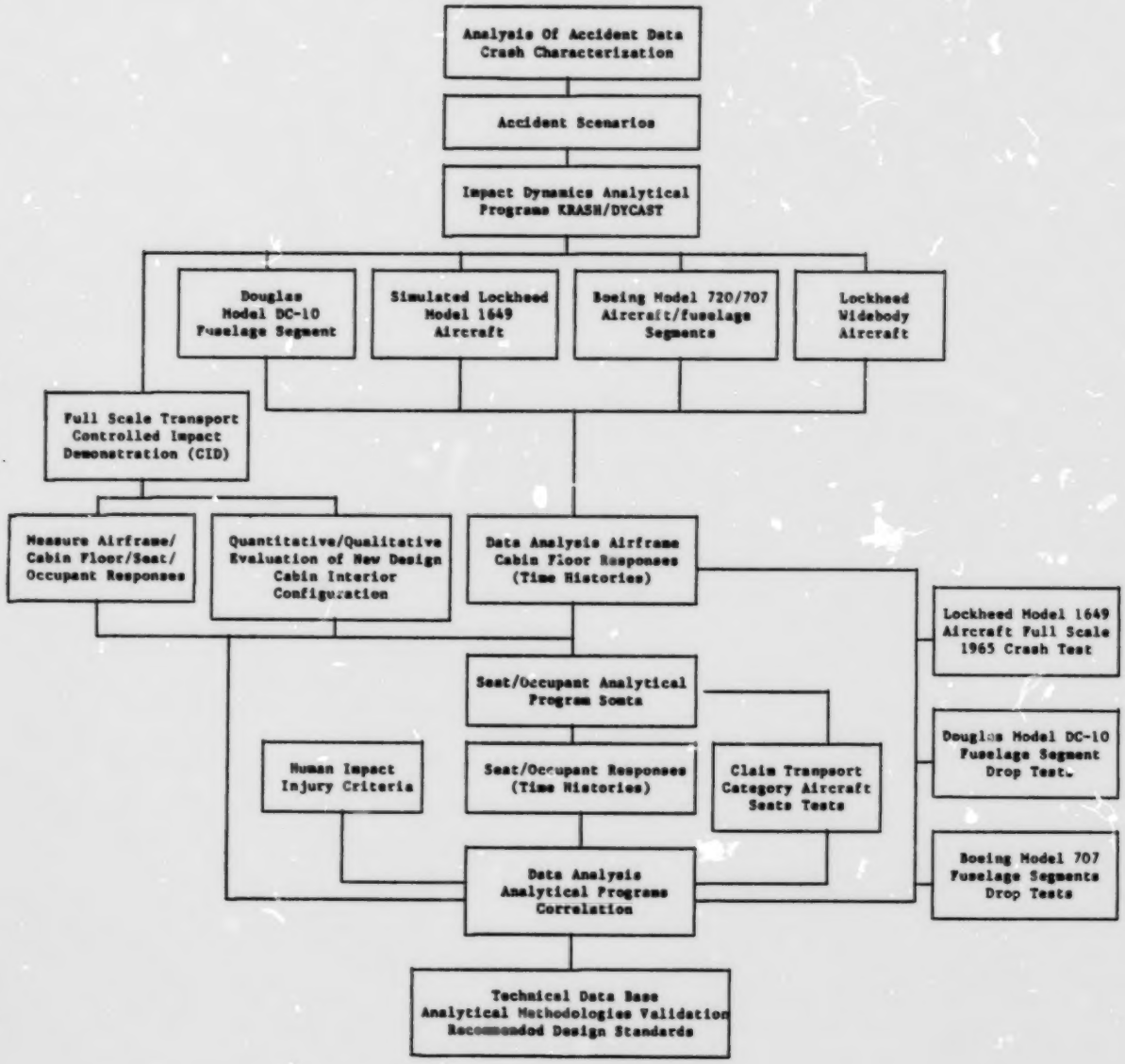

Figure 9-2. FAA Crash Dynamics Engineering and Development Program Transport Airplanes

9.1.4 Retrofit of Existing Small Aircraft

Another aspect of the lack of applicability of the existing crash dynamics data concerns the retrofit of aircraft in flight operations in the U.S. and Canada. The U.S. has approximately 250,000 and Canada about 25,000 aircraft which under existing circumstances will continue to operate without any improvement in crashworthiness because the FAA regulatory policy has not included retrofit. Also, the only known development work has been done by the Jungle Aviation and Radio Service for the Mission Aviation Fellowship (JARS) which operates small aircraft into several remote parts of the world. Unconfirmed reports have been received that the U.S. small aircraft manufacturers have also designed retrofit kits but this information could not be verified except for shoulder harness retrofit kits which FAA approved for three small aircraft manufacturers.

Reference was made in the Chronology of Regulation Section to the pending decision by the DOT Secretary on the most recent FAA recommendations concerning the cost/benefits of retrofitting existing small aircraft with crashworthiness features. If the decision is not to introduce proposed rule-making then it is likely that further research into the means to improve the cost/benefits should be considered, and the JARS experience could serve as a starting point.

9.1.5 Composite Structures

Composite materials are gaining increased use because of their lightness, mechanical properties and ease of adaptability to aircraft structural form. Inflight behaviour of composite structures has been investigated to determine strength qualities, failure mechanisms, fatigue behaviour and damage tolerance. However, less is known about hazards to occupants during crashes which requires knowledge of impact dynamics capabilities. NASA Langley has undertaken to conduct research into impact dynamics of composite transport structures and is utilizing the metal aircraft data as a benchmark for comparison with composite structures. In-house research, contractural work, and university grants are included in the NASA program. It is expected that data will be obtained on laminates, energy absorption, tearing criteria, friction and abrasion, response of cylindrical panels, crushing behaviour of beams, dynamic response of beams and curved frames and substructure. The DYCAST computer program is being utilized for nonlinear finite-element investigations. NASA Technical Memorandum 83691 dated March 1985 discusses the program.

Although these data will have applicability to small aircraft, insufficient research is being directed by any source into composite small aircraft impact dynamics. In fact, although several sources are reported to be active in some aspect of composite impact dynamics of small aircraft it is not easy to obtain a good insight into the subject. Certainly, no evidence was found of a program sponsored by the U.S. government agencies.

NASA believes the results of R&D into small aircraft crashworthiness indicate that crash dynamics is becoming a workable discipline except perhaps for composite structures. The concept of using selective testing together with supportive analysis to assess preliminary design concepts of crash dynamics is feasible and could become a workable design methodology.

9.1.6 Post-Crash Survival

If one reflects upon the objective of crashworthiness which is to save lives and reduce injuries, there is an aspect which only NASA appears to have touched upon, namely the exposure of occupants in crashes occurring in remote areas. Thus, if injuries are reduced and survivability of crash impact improved, it will be to no avail if the searchers cannot locate the wreckage. Accordingly, R&D into survivability after the accident impact is lacking. Such R&D would involve emergency locator transmitters, survival gear design and protection, floatation equipment, etc.

The NASA ELT reference has resulted from work on crash dynamics at NASA Langley Research Center where it was determined that the longitudinal crash environment imposed upon emergency locator transmitters (ELT's) in crash situations is basically a low-frequency loading pulse whereas the frequency response of most ELT's is in the range of frequencies of local structural vibrations of light airplanes. Thus the sensors are often too sensitive causing unwarranted activations or preventing activation during a crash due to the on-off-on-off response. A low-frequency switch design was found to have the desired response characteristics.

9.1.7 Fuel Systems (Post-Crash Fire)

The study of fuel system configuration related to post-crash fires has identified fuel spillage and ignition sources as being the essential ingredients of the database of accident investigations into five related accidents. Fuel spillage can originate in fuel lines, fittings, and fuel tanks during the impact sequence of structural break-up.

Research has disclosed that properly designed fuel systems are achievable to significantly reduce the likelihood of fuel spillage by means of self-sealing fuel cells and shut-off mechanisms in lines and fittings. The cost of such designs in both new and retrofitted aircraft is of concern to the operators and the FAA. In fact the ANPRM described in section 4.3 of the Chronology of Crashworthiness Regulations seeks comments on the effectiveness of the design concepts and their cost-benefits.

The GASP II study of means to prevent post-crash fuel tank spillage has been ongoing since 1984 and is expected to result in recommendations being made to the FAA in 1987. The study is described in a paper entitled General Aviation Aircraft/Fuel System Configuration Study Regarding Fuel Bladder Cell Installation by S. Soltis, FAA, presented at the SAE General Aviation Aircraft Crash Dynamics Meeting held at Wichita, Kansas April 28, 1987.

The components of a crash resistant fuel system include a crashworthy fuel tank, fuel tank fittings, fuel lines, self-sealing breakaway valves and frangible connections. Dr. A.F. Madayag of the FAA Small Airplane Certification Directorate has stated that "a crash resistant fuel system is being pursued to minimize post-crash fire since the system is technically feasible and achievable at this time. The technology relating to the manufacture or production of a crashworthy fuel tank needs further study and research to minimize the reduction in airplane performance, increased weight, and operational problems.

10. PROPOSED R&D PROGRAM AREAS FOR SMALL AIRCRAFT CRASHWORTHINESS IN CANADA

10.1 Introduction

One of the objectives of this study, following a comprehensive review of the status of R&D in this field, was to define "gaps" or areas of R&D in general aviation crashworthiness where further work was required or desireable. To this end six broad areas were identified in Section 9 which included:

- Applicability of Crashworthiness Data/Computer Simulation
- Systems Approach/Coordination
- Retrofit
- Composites
- Post Crash Survival
- Fuel Systems (Post Crash Fire)

It has become clear in the course of this study that the majority of the R&D completed to date has been carried out by U.S. government agencies, industries and institutions. Very little R&D at all has been undertaken in Canada and that which has, has often been done under contract to U.S. government agencies.

For Canada to commence R&D in general aviation crashworthiness presents a quandry. On the one hand, much work already has been started and resident expertise exists in the United States. On the other hand the obligations of the Volpe-Jameson Agreement, recommendations of the Commission of Inquiry in Aviation Safety and the potential safety implications to the passengers travelling in 95% of the aging Canadian fleet, support the need for a further serious look at the potential Canadian contribution in general aviation crashworthiness R&D.

Canada does not have a general aviation manufacturing industry to speak of, however, it does certificate and test general aviation aircraft imported to this county. Although, it is unrealistic to aspire to be in a position to independently test all new products, some R&D is necessary to ensure that these aircraft meet any special Canadian requirements.

10.2 Proposed Program Areas

In the course of this study, discussions were held with key Canadian and American participants with significant interest in general aviation crashworthiness R&D. The consensus amongst U.S. researchers was that much work remained to be done, more cooperation was in order, they would welcome a Canadian contribution in any area, and that some of the work already completed (notably the University of Toronto's computer modelling) was considered useful. With respect to what program areas they considered appropriate for Canadian participation, no specific response was given. This was attributed on the whole to the general lack of knowledge of Canadian R&D in general aviation crashworthiness.

From the Canadian perspective, (principally that of government agencies), it was concluded that Canada did indeed have an interest in small aircraft crashworthiness R&D and should to the extent possible make some form of contribution to international efforts in this area. It was also a concensus that any initiatives pursued should be in areas of "Canadian" interest. Consequently the "gaps" in R&D which were identified in Section 9 served as a basis to re-examine which, if any areas would be of particular value to Canada or which constituted areas where there was existing R&D capability to build on.

Figure 10-1 illustrates the decision process which resulted in the identification of potential candidate program areas for Canadian initiatives in small aircraft crashworthiness R&D. The six areas identified as "gaps" (primarily by U.S. researchers) were evaluated in light of the concerns expressed by the government, industry and institutional researchers interviewed in Canada. The factors to be considered in identifying potential program areas for small aircraft crashworthiness R&D were as follows:

- The general aviation fleet, comprises approximately 95% of the total number of aircraft in Canada. Most types are certificated under CAR 3;
- The high cost of replacement aircraft and the financial situtation of private operators and small air carriers makes it highly unlikely that newer aircraft will replace the existing ones in the near future;
- Small aircraft in Canada, more often than in the U.S. operate in sparsely settled regions;
- The conditions in which small aircraft operate in Canada are more severe than those in the U.S.;
- The likelihood of small aircraft accidents occurring in inaccessible areas is higher in Canada than in the U.S.;
- The CASB and other government agencies have, to some degree taken environmental considerations into the development of existing programs, e.g., ELT, R&D;
- Transport Canada as a regulatory body has a requirement to draw upon R&D and engineering work specifically related to special Canadian conditions;
- Pockets of small aircraft crashworthiness R&D expertise exist in Canada, and
- In the absence of a domestic general aviation manufacturing industry, and a legal liability suit history, Canada is in a position to facilitate coordination of R&D in this field.

Taking the above factors into consideration, two candidate program areas for Canadian initiative in small aircraft crashworthiness R&D were identified:

EXISTING R&D "GAPS" IN SMALL AIRCRAFT CRASHWORTHINESS R&D	→	CANADIAN CONSIDERATIONS/ SPECIAL FACTORS	→	CANDIDATE PROGRAM AREAS FOR CANADIAN INITIATIVE IN SMALL AIRCRAFT CRASHWORTHINESS R&D
. Applicability of Crashworthiness Data/Computer Simulation		. Age of General Aviation Fleet		. Retrofit/Partial Retrofit
. Systems Approach/Coordination		. High Cost of Replacement		. Post-Crash Survival
. Retrofit		. Canadian Environmental Conditions		
. Composites (New Materials)		. Accident Locales		
. Post-Crash Survival		. Existing Institutional Expertise		
. Fuel Systems (Post-Crash Fire)		. Regulatory Need		
		. Existing Canadian Expertise		
		. Impartiality - no major manufacturers		

Figure 10-1. Decision Process to Identify Potential Candidate Program Areas for Canadian Initiative in Small Aircraft Crashworthiness R&D

1. Retrofit/Partial Retrofit
2. Post Crash Survival

10.3 Institutional Considerations

10.3.1 U.S. Characteristics

Much of the success and advancement of small aircraft crashworthiness R&D in the United States can be attributed to dedicated research managers, a degree of dedicated funding and a history of established roles, mandates and working relationships between government, industry, the military, academic institutions and associations. There have been, and are presently, a wide variety of players pursuing different aspects of R&D. While managers have cited the need for greater coordination, the programs have generally produced results because of several "institutional" characteristics - characteristics which to a great extent were absent in Canada. While some of these features are unique to the United States, e.g., a highly developed general aviation manufacturing industry, extensive military funding, space program support, etc. many others are managerial in nature and could exist in Canada.

The key factors contributing to the success of U.S. R&D in small aircraft crashworthiness are as follows:

1. A highly developed general aviation manufacturing industry;

2. Funding and joint working relationships with the military in areas of interest to the military, e.g., helicopter crashworthiness;

3. Funding and joint working relationships with NASA (Space Program) on areas of interest/benefit to NASA;

4. A highly developed and local network of consumer groups and professional associations concerned with general aviation crashworthiness;

5. A large number of universities with undergraduate and graduate programs in aeronautical science and engineering producing a large group of highly trained individuals;

6. Extensive cooperative arrangements/interchange/financial support between government agencies and academic/technical institutions;

7. A high degree of continuous contracting out of R&D in specialized areas e.g. post crash fire;

8. Clearly defined agency roles, mandates and responsibilities e.g. medical R&D - CAMI, crash dynamics - NASA, regulatory FAA, etc.;

9. Programmed financial commitments in most cases corresponded to logical program conclusions. Three to four year funding horizon, and

10. Well founded accident investigation procedures and data collection specifically related to general aviation crashworthiness.

Two overall driving forces were acknowledged as being responsible for producing significant advances in crashworthiness R&D during the past decade - knowledgeable consumer "activism" which could be traced to Ralph Nader was heralded on the demand side and the existence of a "champion" in the person of Administrator Lynn Helms was key on the "response" side. The existence of the latter served as a catalyst in ensuring the development of clearly defined agency roles, mandates, funding and visibility.

10.3.2 Canadian Characteristics

Discounting the unique U.S. features of military and space program support, and the existence of a highly developed ground aviation manufacturing industry, managers in Canada cited the need for the following to ensure the advancement of crashworthiness R&D:

1. An identifiable "lead" agency for small aircraft crashworthiness R&D;

2. Clearly defined roles, responsibilities mandates for existing and future participants e.g. Transport Canada, CASB, TDC, NAE, DND, etc.;

3. Earmarked and consistent funding sufficient to cover defined R&D programs;

4. Closer cooperation with the U.S. agencies and researchers in the field;

5. The development of a compatible accident reporting system (crashworthiness) with the United States to facilitate data sharing, and

6. The development of a strong government - university - industry relationship through cooperative R&D programs related to general aviation crashworthiness.

10.4 Conclusions

1. There is an obligation under various Canada-U.S. bilateral agreements to cooperate in areas of aeronautical research and development.

2. The Report of the Commission of Inquiry into Aviation Safety and subsequent studies identified airworthiness of small aircraft as an area where safety could be significantly improved.

3. Research and development in small aircraft crashworthiness is an area which is of relevance to Canada and one in which a significant contribution to international R&D efforts could be made.

4. To-date, most R&D in general aviation crashworthiness has been carried out in the United States. Very little R&D has been completed in Canada.

5. Existing "gaps" or areas in which further R&D is desireable in the field of general aviation crashworthiness area as follows:

   (a) applicability of crashworthiness data; computer simulation and modelling;

   (b) development of a rigorous systems approach, coordination of efforts;

   (c) retrofit;

   (d) composites (new materials);

   (e) post-crash survival;

   (f) fuel systems (post-crash fire).

6. Of the "gaps" identified in 5. above, two areas were identified as potential candidates for Canadian R&D. These areas were:

   (a) retrofit, and

   (b) post-crash survival.

   To a lesser extent, certain aspects of composites R&D and systems approach/coordination would also be in the Canadian interest.

7. Of equal importance to the identification of candidate program areas for R&D cooperation is the need to establish clearly defined roles, and responsibilities of the government agencies, institutions and industries involved in carrying out R&D in small aircraft crashworthiness. To-date, in Canada, many of these roles, relationships and responsibilities remain unclear, thus detracting from the effectiveness of an R&D program.

10.5 Recommendations

Recommendations from the report are made in the three areas - overall "general" recommendations, recommendations with respect to potential program areas, and institutional recommendations. These are as follows:

General

1. It is recommended that Canada, in the interests of improving safety of general aviation aircraft, increase its contribution to internatinal R&D in the area of small aircraft crashworthiness.

R&D Program Areas

It is recommended that:

1. A general aviation crashworthiness R&D program should be set up in Canada.

2. Retrofit and/or Post-Crash survival R&D should be the primary focus of work to be undertaken in Canada.

3. A benefit/cost analysis should be carried out to ascertain the impact upon safety of undertaking each R&D program.

4. Prior to program delineation, the FAA and/or other appropriate U.S. agencies should be consulted with respect to their future plans in these areas.

Institutional

It is recommended that:

1. The National Aeronautical Establishment (NEA) should become the lead agency for small aircraft crashworthiness R&D.

2. Transport Canada/TDC should sponsor a small aircraft crashworthiness workshop to explore the development of a Canadian crashworthiness R&D program.

3. Transport Canada should sponsor a Standing Committee under the aegis of an NRC Associate Committee to review and coordinate long-term Canadian crashworthiness activities.

4. Transport Canada/TDC should dedicate funds for crashworthiness R&D.

5. The NAE with the assistance of the proposed Crashworthiness R&D Associate Committee should develop a program to monitor the U.S. R&D agencies other than the FAA.

6. Transport Canada should review the Volpe-Jamieson Agreement and its amendments to determine if it is appropriate for a TC-FAA cooperative approach into small aircraft crashworthiness whereby each agency would agreed to take a lead role in specific gaps in small aircraft crashworthiness R&D.

7. The CASB should explore with the U.S. National Transportation Safety Board the development of a compatible accident reporting system.

8. Industry cooperation through associations such as the Air Industries Association of Canada (AIAC) be considered.

APPENDIX 1

NTSB Factual Report
Aviation Accident/Incident

FACTUAL REPORT
AVIATION
ACCIDENT/INCIDENT

National Transportation Safety Board
Washington, D.C. 20594

NTSB Form 6120.4

Instructions

Unless otherwise stated in the instructions or on the form, all data fields must be completed. Each data field requires either a direct entry or the entry of one or more x's in appropriate blocks that best describe the mishap circumstances. Multiple entry fields may require two or more responses. Enter all applicable responses in multiple entry fields. When the selections offered are inappropriate, a two digit "other" code shall be entered in the space that follows the word "other." Do not make additional remarks in the margins as the automated data processor is not programmed to accept them. Any information which is needed to outline the sequence of events which preceded the occurrence, to support probable cause determination or which is pertinent to crashworthiness studies should be addressed in the narrative report.

"Other" Codes

01	Limited access to and/or limited time available at site.
02	Aircraft not recovered/missing.
03	Part/component not recovered/not located.
04	Aircraft too badly damaged to determine.
05	Part/component too badly damaged to determine.
06	Information not pertinent to accident/incident.
07	Applicable personnel could not provide information or information not available to applicable personnel.
08	Applicable personnel would not provide information.
09	Not installed.
10	Records not located/not available.
11	Information not entered on NTSB Form 6120.1.
12	See narrative report.

Supplements

The following accident scenarios are provided to assist investigators in selecting the report forms which should supplement the basic NTSB Form 6120.4.

1. A Cessna 172 collided with a snowbank during landing goaround at an airport. Weather was not a factor. The pilot said there was no powerplant or control malfunction. The pilot and one passenger received minor injuries. The pilot had recently been certificated as a private pilot.

Complete supplemental forms F (Training and Proficiency), Q (Airport) and S (Occupant list). A "Limited" investigation should be completed.

2. A PA-31, being operated by two pilots under FAR 135, crashed into a tower while being vectored to intercept the localizer at the destination airport. The PA-31 struck the tower while being operated at an assigned altitude. Flight was in IMC. There were two fatal injuries and three serious injuries. CFR personnel responded and treated the injured.

This accident requires an onscene investigation. Thus supplement A (Wreckage documentation), B (Cockpit documentation) and I (Crash kinematics) are required. Supplements E (Second pilot), F (Training and Proficiency) and U are required because of the two pilot FAR 135 operation (even though proficiency may not be at issue). S is needed to list the occupants; T, to document the CFR activity and P, to cover the possible ATC involvement. R (Meteorology) is required to document the weather conditions. Copies of supplements K and L would be required to document injury/toxicology and seat/restraint damage information, respectively.

National Transportation Safety Board

FACTUAL REPORT
AVIATION

1 NTSB Accident/Incident Number

2
1 ☐ Accident
2 ☐ Incident

3 Investigation
1 ☐ NTSB
2 ☐ FAA Delegated

4 Aircraft Registration Number	**5 Flight Number** _____ A Other	*For collision between aircraft, enter reg. no. and flt. no. for other aircraft*	**6 Aircraft Registration Number**	**7 Flight Number** _____ A Other

8 Nearest City/Place	**9 State**	**10 Zip Code** *(First 5 numbers only)*	**11 Accident Site Elevation** _____ Feet MSL

12 Date of Accident *(Nos. for M, D, Y)*	**13 Day of Week** *(First 2 letters)*	**14 Local Time** *(24 hour clock)*	**15 Time Zone**

16 Narrative Statement of Facts, Conditions and Circumstances Pertinent to the Accident/Incident

Additional Persons Participating in this Accident/Incident Investigation *(Name, address, affiliation, Continue on page 2 if necessary)*

17 Date *(Nos. for M, D, Y)*	**18 Agency**	**19 Name/Signature**

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

16 Narrative Statement of Facts, Conditions and Circumstances Pertinent to the Accident/Incident *(continued)*

Attach additional pages as necessary (Page 2a, 2b, 2c, etc.)

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Airport/Approach/Landing Information

24 ☐ Not applicable *(Go to block 39)*

25 Airport Name
_____
A Other

26 Airport Identifier
_____

27 Accident Location
1 ☐ Off airport/airstrip
2 ☐ On airport
3 ☐ On airstrip
A Other

28 Distance From Airport Center *(Nearest SM)*
_____ SM
A Other

29 Direction From Airport
_____ °mag
A Other

30 VFR Approach/Landing *(Multiple entry)*
1 ☐ None
2 ☐ Traffic pattern
3 ☐ Straight-in
4 ☐ Valley/terrain following
5 ☐ Go around
6 ☐ Touch and go
7 ☐ Full stop
8 ☐ Stop and go
9 ☐ Simulated forced landing
10 ☐ Forced landing
11 ☐ Precautionary landing
A Other

31 Type Instrument Approach Flown *(Multiple entry)*
1 ☐ None
2 ☐ ADF/NDB
3 ☐ SDF
4 ☐ VOR/TVOR
5 ☐ VOR/DME
6 ☐ TACAN
7 ☐ ILS-complete
8 ☐ ILS-localizer
9 ☐ ILS-backcourse
10 ☐ RNAV
11 ☐ MLS
12 ☐ LDA
13 ☐ ASR
14 ☐ PAR
15 ☐ Sidestep
16 ☐ Visual
17 ☐ Contact
18 ☐ Circling
19 ☐ Practice
A Other

32 Runway Used Identifier
_____
A Other

33 Runway Length
_____ Feet
A Other

34 Runway Width
_____ Feet
A Other

35 Airport Elevation
_____ Ft. MSL
A Other

36 Runway/Landing Surface
1 ☐ Macadam
2 ☐ Asphalt
3 ☐ Concrete
4 ☐ Gravel
5 ☐ Dirt
6 ☐ Grass/turf
7 ☐ Snow
8 ☐ Ice
9 ☐ Water
10 ☐ Metal/wood
A Other

37 Runway/Landing Surface Condition
1 ☐ Dry
2 ☐ Wet
3 ☐ Ice covered
4 ☐ Snow—dry
5 ☐ Snow—wet
6 ☐ Snow—crusted
7 ☐ Snow—compacted
8 ☐ Vegetation
9 ☐ Water—calm
10 ☐ Water—choppy
11 ☐ Water—glassy
12 ☐ Rubber deposits
13 ☐ Soft
14 ☐ Rough
15 ☐ Slush covered
16 ☐ Holes
A Other

If accident occurred during approach, departure or on airport, see instructions for completing Supplement Q.

Aircraft Information

38 Aircraft Manufacturer

40 Aircraft Model/Series

41 Serial No.
_____
A Other

42 Certificated Maximum Gross Weight
_____
A Other

43 Type of Aircraft
1 ☐ Airplane
2 ☐ Helicopter
3 ☐ Glider
4 ☐ Balloon
5 ☐ Blimp/dirigible
6 ☐ Ultralight
7 ☐ Gyroplane
A Specify
_____

44 Type Airworthiness Certificate *(Multiple entry)*

Standard
1 ☐ Normal
2 ☐ Utility
3 ☐ Acrobatic
4 ☐ Transport

Special
5 ☐ Restricted
6 ☐ Limited
7 ☐ Provisional
8 ☐ Special flight
9 ☐ Experimental

A Other

45 Home Built
1 ☐ Yes
2 ☐ No
A Other

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Aircraft Information (continued)

46 Landing Gear *(Multiple entry)*

1 ☐ Tricycle—fixed
2 ☐ Tricycle—retractable
3 ☐ Tailwheel—all fixed
4 ☐ Tailwheel—all retractable
5 ☐ Tailwheel—retractable mains
6 ☐ Amphibian
7 ☐ Hull
8 ☐ Float
9 ☐ Emerg. float
10 ☐ Ski
11 ☐ Ski/wheel
12 ☐ Skid
13 ☐ High Skid
A Other

48 No. of Seats
_____
A Other

49 Stall Warning System Installed
1 ☐ Yes
2 ☐ No
A Other

50 IFR Equipped
1 ☐ Yes
2 ☐ No
A Other

51 Icing Certification/Equipped *(Multiple entry)*
1 ☐ Certified
2 ☐ Not Certified
3 ☐ Equipped
4 ☐ Not Equipped
A Other

52 Engine Type
1 ☐ Reciprocating—carburetor
2 ☐ Reciprocating—fuel injected
3 ☐ Turbo prop
4 ☐ Turbo jet
5 ☐ Turbo fan
6 ☐ Turbo shaft
A Other

If not Engine powered, go to block 59

53 Engine Manufacturer

54 Engine Model and Series

55 Engine Rated Power
A _____ Horsepower
B _____ Lbs. Thrust
C Other

56 Number of Engines
_____
A Other

If 3 or more engines enter times in Supp. C

Engine Time (Hours)	A Total Time	B Time Since Inspection	C Time Since Major Overhaul	D Other
57 Engine No. 1				
58 Engine No. 2				

59 Type Maintenance Program
1 ☐ Annual
2 ☐ Manufacturer's Inspection Program
3 ☐ Other approved inspection program (AAIP)
4 ☐ Continuous airworthiness
A Other

60 Type of Last Inspection
1 ☐ Annual
2 ☐ 100 hour
3 ☐ AAIP
4 ☐ Continuous airworthiness
A Other

61 Date Last Inspection Performed *(Nos. for M, D, Y)*
_____
A Other

62 Time Since Inspection
_____ Hours
A Other

63 Airframe Total Time
_____ Hours
A Other

64 Source of Maintenance Information
1 ☐ Tach
2 ☐ Flight
3 ☐ Hobbs
4 ☐ Logbooks Records
5 ☐ Estimate
6 ☐ Pilot/Operator Report
A Other

65 Hazardous Materials on Aircraft
1 ☐ No
A *(Type)* _____
B Other

66 Hazardous Material Spill/Factor
1 ☐ Yes
2 ☐ No
A Other

Emergency Locator Transmitter (ELT)	1 Yes	2 No	A Other
67 Installed			
68 Required			
69 Operated			
70 Aided in location of accident site			

Owner/Operator Information

71 Registered Aircraft Owner
Name

72 Address

73 Operator of Aircraft 1 ☐ Same as registered owner
A Name:
B dba
C Other

74 Address 1 ☐ Same as registered owner
A _____
_____
B Other

75 Operator Certificate No.
_____
A Other

76 Operator Designator Code

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Owner/Operator Information *(continued)*

77 Operator Status of This Aircraft
1 [ ] Owner
2 [ ] Lessee
3 [ ] Renter
4 [ ] Borrower
5 [ ] Unauthorized
A Other

78 Pilot Status of This Aircraft
1 [ ] Owner
2 [ ] Lessee
3 [ ] Renter
4 [ ] Borrower
5 [ ] Unauthorized
6 [ ] Employee
A Other

Type of Certificate(s) Held

79 None [ ] *(Go to block 83)*

80 Air Carrier Operating Certificate *(Check all applicable)*
1 [ ] Flag carrier/domestic (121)
2 [ ] Supplemental
3 [ ] All cargo (418)
4 [ ] Large helicopter (127)
5 [ ] Commuter air carrier
6 [ ] On-demand air taxi

81 Operating Certificate
[ ] Other operator of large aircraft

82 Operator Certificate
1 [ ] Rotorcraft—external load operator (13
2 [ ] Agricultural aircraft (137)

Regulation Flight Conducted Under

83 Regulation Flight Conducted Under
1 [ ] 14 CFR 91 *(only)*
2 [ ] 14 CFR 91D
3 [ ] 14 CFR 103
4 [ ] 14 CFR 105
5 [ ] 14 CFR 121
6 [ ] 14 CFR 125
7 [ ] 14 CFR 127
8 [ ] 14 CFR 133
9 [ ] 14 CFR 135
10 [ ] 14 CFR 137
11 [ ] 14 CFR 129 *(Foreign flag)*
A Specify

Type of Flight Operation Conducted

*(Complete 84a, b, c **ONLY** if flight was a revenue operation conducted under 121, 125, 127, 129, 135)*

84a
1 [ ] Scheduled
2 [ ] Non-scheduled

84b
1 [ ] Domestic
2 [ ] International

84c
1 [ ] Passenger
2 [ ] Cargo
3 [ ] Passenger/cargo
4 [ ] Mail contract ONLY

*(Complete 86 **ONLY** if 84a, b, c is not applicable)*

86
1 [ ] Personal
2 [ ] Business
3 [ ] Instructional *(Including air carrier training)*
4 [ ] Executive/corporate
5 [ ] Aerial application
6 [ ] Aerial observation
7 [ ] Other work use
8 [ ] Public use
9 [ ] Ferry
10 [ ] Positioning
A Specify _____

First Pilot Information

87 Name *(Last, First, Initial)*
_____
A Other

88 Pilot Certificate No.
_____
A Other

89 Street Address
_____
A Other

90 City
_____
A Other

91 State

92 Date of Birth *(Nos. for M, D, Y)*
_____
A Other

93 Age
_____ Yrs.
A Other

94 Sex
1 [ ] Male
2 [ ] Female

95 Seat Occupied
1 [ ] Left
2 [ ] Right
3 [ ] Center
4 [ ] Front
5 [ ] Rear
A Other

96 Principal Profession
1 [ ] Pilot—civilian
2 [ ] Pilot—military
3 [ ] Other—military
4 [ ] Aircraft mechanic
5 [ ] Business
6 [ ] Lawyer
7 [ ] Doctor/dentist
8 [ ] Police
9 [ ] Student
10 [ ] Clergy
11 [ ] Teacher
12 [ ] Engineer
13 [ ] Farmer/rancher
14 [ ] Retired
A Other

97 Certificate(s) *(Multiple entry)*
1 [ ] Student
2 [ ] Private
3 [ ] Commercial
4 [ ] Airline Transport
5 [ ] Flight Instructor
6 [ ] Flight Engineer
7 [ ] Military
8 [ ] None
9 [ ] Foreign
A Other

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

First Pilot Information *(continued)* *(Multiple entry - blocks 98-102)*

98 Ratings—Airplane
1 ☐ None
2 ☐ Single engine land
3 ☐ Multiengine land
4 ☐ Single engine sea
5 ☐ Multiengine sea

99 Rotorcraft/Glider/LTA
1 ☐ None
2 ☐ Helicopter
3 ☐ Gyroplane
4 ☐ Airship
5 ☐ Free balloon
6 ☐ Glider

100 Instrument Rating
1 ☐ None
2 ☐ Airplane
3 ☐ Helicopter

101 Instructor Rating(s)
1 ☐ None
2 ☐ Airplane SE
3 ☐ Airplane ME
4 ☐ Helicopter
5 ☐ Gyroplane
6 ☐ Glider
7 ☐ Instrument plane
8 ☐ Instrument helicopter

102 Ground Instructor
1 ☐ None
2 ☐ Basic
3 ☐ Advanced
4 ☐ Instrument

103 Type Rating Endorsement This Aircraft
1 ☐ Yes
2 ☐ No *(Go to block 105)*
A Other

104 Months Since Check/Endorsement This Aircraft
_____ Months
A Other

105 Biennial Flight Review *(Or equivalent)*
1 ☐ Yes
2 ☐ No
A Other

106 Months Since Last BFR
_____ Months
A Other

107 BFR *(or equivalent)* **Aircraft Make/Model**
A Make _____
B Model _____
C Other

108 Medical Certificate
1 ☐ None
2 ☐ Class 1
3 ☐ Class 2
4 ☐ Class 3
A Other

109 Medical Certificate Validity
1 ☐ Valid medical—no waivers/limitations
2 ☐ Valid medical—with waivers/limitations
3 ☐ Non valid medical for this flight
4 ☐ Expired
5 ☐ No medical certificate
A Other

110 Date of Last Medical *(Nos. for M, D, Y)*
_____
A Other _____

111 Medical limitation
1 ☐ None
2 ☐ Vision
A Specify
_____
B Other

112 Medical waiver
1 ☐ None
2 ☐ Vision
3 ☐ Hearing
A Specify _____
B Other

113 Statement of Demonstrated Ability
1 ☐ Yes
2 ☐ No
A Other

114 Correcting Lenses *(Multiple entry)*
1 ☐ Not required
2 ☐ Required to be in possession
3 ☐ Required, not in possession
4 ☐ Required to be worn
5 ☐ Required, not worn
6 ☐ Worn at time of accident
A Other

115 Source of Pilot Flight Time *(Multiple entry)*
1 ☐ Pilot log
2 ☐ Company
3 ☐ FAA
4 ☐ Pilot/Operator Report
5 ☐ Investigator's Estimate
6 ☐ Relative
7 ☐ Other Person
A Other

Flight Time	A All A/C	B This Make & Model	C Airplane Single Engine	D Airplane Multiengine	E Night	F Instrument Actual	G Instrument Simulated	H Rotorcraft	I Glider	J Lighter Than Air	K Other
125 Total Time											
126 Pilot in Command (PIC)											
127 Instructor											
128 This Make/Model											
129 Last 90 Days											
130 Last 30 Days											
131 Last 24 Hours											

132 Landings—Last 90 Days All Aircraft
_____ Day
A Other

133 Landings—Last 90 Days All Aircraft
_____ Night
A Other

134 Landings—Last 90 Days This Make/Model
_____ Day
A Other

135 Landings—Last 90 Days This Make/Model
_____ Night
A Other

136 Seatbelt Available
1 ☐ Yes
2 ☐ No
A Other

137 Seatbelt Used
1 ☐ Yes
2 ☐ No
A Other

138 Shoulder Harness Available
1 ☐ Yes
2 ☐ No
A Other

139 Shoulder Harness Used
1 ☐ Yes
2 ☐ No
A Other

140 Autopsy Performed *(This pilot)*
1 ☐ Yes
2 ☐ No
A Other

141 Toxicology Performed *(This pilot)*
1 ☐ Yes
2 ☐ No
A Other

National Transportation Safety Board

FACTUAL REPORT AVIATION

NTSB Accident/Incident Number

Pilot Information (continued)

142 Person at Controls
1 ☐ Pilot in command
2 ☐ Second pilot
3 ☐ Both pilots
4 ☐ Non-pilot
5 ☐ No one
A Other

143 Simulated Instrument Flight
1 ☐ Yes
2 ☐ No
A Other

144 Vision Restricting Device Used
1 ☐ Yes
2 ☐ No
A Other

145 Second Pilot
1 ☐ Yes *(Complete second pilot supplement)*
2 ☐ No

Flight Itinerary Information

155 Last Departure Point *(Multiple entry)*
1 ☐ Same as accident/incident location or
A Airport identifier _____
B City/Place _____
C State
D Other

156 Time of Departure
A Time _____
B Time Zone _____
C Other

157 Destination *(Multiple entry)*
1 ☐ Same as accident/incident location or
2 ☐ Local flight
A Airport Identifier _____
B City/Place _____
C State _____
D Other

158 Flight Plan Filed *(Multiple entry)*
1 ☐ None
2 ☐ Visual Flight Rules (VFR)
3 ☐ Instrument Flight Rules (IFR)
4 ☐ VFR/IFR
5 ☐ Company (VFR)
6 ☐ Military (VFR)
A Other

159 Type of Clearance
1 ☐ None
2 ☐ VFR
3 ☐ Special VFR
4 ☐ IFR
5 ☐ Special IFR
6 ☐ VFR on top
7 ☐ Cruise
8 ☐ Traffic Advisory
9 ☐ VFR Flight Following
A Other

160 Airspace
1 ☐ Uncontrolled
2 ☐ Controlled
3 ☐ Airport traffic area
4 ☐ Control zone
5 ☐ Airport advisory area
6 ☐ Positive control area
7 ☐ Terminal control area
8 ☐ Stage II TRSA
9 ☐ Stage III TRSA
10 ☐ Prohibited area
11 ☐ Restricted area
12 ☐ Military Operating Area (MOA)
13 ☐ Student Jet Training Area
14 ☐ Demo Area
15 ☐ Warning area
16 ☐ FAR 93 (Special air traffic areas)
A Other

161 Control Area
1 ☐ None
2 ☐ Victor airway
3 ☐ Jet airway
4 ☐ Control airway
5 ☐ Colored airway
A Other

162 Route
1 ☐ None
2 ☐ Standard instrument departure
3 ☐ Standard terminal arrival
4 ☐ RNAV/OMEGA/LCRAN/INS
5 ☐ Direct
6 ☐ Profile Descent
7 ☐ VR route (military)
8 ☐ IR route (military)
9 ☐ SR route (military)
10 ☐ Refueling route (military)
A Other

163 Last Two Way Communications Established
1 ☐ None
2 ☐ Yes
A Facility Identifier _____
B Other

Aircraft Loading Information

164 Fuel on Board at Takeoff *(Multiple entry)*
1 ☐ Estimated
2 ☐ Verified
A _____ Gallons or
B _____ Pounds
C Other

165 Fuel Types *(Multiple entry)*
1 ☐ 80/87
2 ☐ 100 low lead
3 ☐ 100/130
4 ☐ 115/145
5 ☐ Kerosene
6 ☐ JP 3, 4, 5, 6
7 ☐ Jet A
8 ☐ Jet B
9 ☐ Mixture
10 ☐ Automotive
11 ☐ Anti-ice additive added *(If known)*
A Other

166 Aircraft Weight at Takeoff *(Multiple entry)*
1 ☐ At or below max cert. gross takeoff weight
2 ☐ Above max certified gross takeoff weight
3 ☐ Estimated
4 ☐ Verified
A Other

167 Aircraft CG at Takeoff *(Multiple entry)*
1 ☐ Within limits
2 ☐ Exceeded fwd limit
3 ☐ Exceeded aft limit
4 ☐ Exceeded lateral limit
5 ☐ Estimated
6 ☐ Verified
A Other

168 Aircraft Weight at Accident *(Multiple entry)*
1 ☐ Same as takeoff
2 ☐ At or below max cert. gross takeoff weight
3 ☐ Above max certified gross takeoff weight
4 ☐ Estimated
5 ☐ Verified
A Other

169 Aircraft CG at Accident *(Multiple entry)*
1 ☐ Same as takeoff
2 ☐ Within limits
3 ☐ Exceeded fwd limit
4 ☐ Exceeded aft limit
5 ☐ Exceeded lateral limit
6 ☐ Estimated
7 ☐ Verified
A Other

National Transportation Safety Board

FACTUAL REPORT AVIATION

NTSB Accident/Incident Number

Aircraft Loading Information (Continued)

170 Load Description *(Multiple entry)*

1 ☐ None
2 ☐ Passengers
3 ☐ Cargo
4 ☐ Towing glider
5 ☐ Towing banner
6 ☐ Other external
7 ☐ Parachutists
8 ☐ Water
9 ☐ Chemical
10 ☐ Livestock
11 ☐ Illegal cargo
A Other

Weather Information

180 Source of Weather Briefing *(Multiple entry)*

1 ☐ No record of briefing *(Go to block 183)*
2 ☐ National Weather Service (NWS)
3 ☐ Flight Service Station
4 ☐ PATWAS (Pilot Automated Tel. WX Answering Svc)
5 ☐ VRS (Voice Response System)
6 ☐ Company
7 ☐ Commercial weather service
8 ☐ TV/radio weather
9 ☐ Military
A Other

181 Method of Briefing *(Multiple entry)*

1 ☐ In person
2 ☐ Teletype
3 ☐ Telephone
4 ☐ Aircraft radio
5 ☐ TV/radio
A Other

182 Completeness of Weather briefing

1 ☐ Weather not pertinent
2 ☐ Full
3 ☐ Partial—limited by pilot
4 ☐ Partial—limited by briefer/forecaster
A Other

183 Investigator's Source of Weather Information

1 ☐ Pilot *(Go to block 185)*
2 ☐ Witness *(Go to block 185)*
3 ☐ Weather observation facility

184 Weather Observation Facility

A Identifier _____
B Time of observation _____ zone _____
C Elevation _____ feet MSL
D Distance from accident site _____ NM
E Direction from accident site _____ °magnetic

185 Basic Weather Conditions at Accident Site

1 ☐ Visual Meteorological Conditions (VMC)
2 ☐ Instrument Meteorological Conditions (IMC)
A Other

186 Conditions of Light

1 ☐ Dawn
2 ☐ Daylight
3 ☐ Night (Dark)
4 ☐ Night (Bright)
5 ☐ Dusk
A Other

187 Sky/Lowest/Cloud Condition

1 ☐ Clear
2 ☐ Scattered
3 ☐ Thin broken
4 ☐ Thin overcast
5 ☐ Partial obscuration
A _____ Feet AGL
B Other

188 Lowest Ceiling

1 ☐ None
2 ☐ Broken
3 ☐ Overcast
4 ☐ Obscured
A _____ Feet AGL
B Other

189 Visibility *(decimals)*

A _____ SM
B RVR _____ Feet
C RVV _____ SM
D Other

190 Temperature

_____ ° F
A Other

191 Dew Point

_____ ° F
A Other

192 Wind (From)

1 ☐ Variable
A _____ ° Magnetic
B Other

193 Wind Speed

1 ☐ Calm
2 ☐ Light and Variable
A _____ Kts.
B Other

194 Gusts

1 ☐ None
A _____ Kts.
B Other

195 Altimeter Setting

_____ " Hg
A Other

196 Density Altitude

_____ Feet
A Other

197 Restrictions to Visibility

1 ☐ None
2 ☐ Haze (H)
3 ☐ Dust (D)
4 ☐ Smoke (K)
5 ☐ Fog (F)
6 ☐ Ice fog (IF)
7 ☐ Ground fog (GF)
8 ☐ Blowing spray (BY)
9 ☐ Blowing dust (BD)
10 ☐ Blowing snow (BS)
11 ☐ Blowing sand (BN)
A Other

198 Type of Precipitation

1 ☐ None *(Go to block 200)*
2 ☐ Rain (R)
3 ☐ Snow (S)
4 ☐ Hail (A)
5 ☐ Rain showers (RW)
6 ☐ Freezing rain (ZR)
7 ☐ Snow shower (SW)
8 ☐ Drizzle (L)
9 ☐ Ice pellets (IP)
10 ☐ Snow pellets (SP)
11 ☐ Snow grains (SG)
12 ☐ Freezing drizzle (ZL)
13 ☐ Ice crystals (IC)
14 ☐ Ice pellet shower (IPW)
A Other

199 Intensity of Precipitation

1 ☐ Light
2 ☐ Moderate
3 ☐ Heavy
A Other

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Accident Information

200 Aircraft Damage
1 ☐ None
2 ☐ Minor
3 ☐ Substantial
4 ☐ Destroyed

201 Aircraft Fire
1 ☐ None
2 ☐ In-flight
3 ☐ On ground
A Other

202 Explosion
1 ☐ None
2 ☐ In-flight
3 ☐ On ground
A Other

203 Damage to Property
1 ☐ None
2 ☐ Residence
3 ☐ Residential area
4 ☐ Commercial bldg.
5 ☐ Vehicle(s)
6 ☐ Airport facility
7 ☐ Trees
8 ☐ Crops
9 ☐ Fence
10 ☐ Wires/poles
11 ☐ Other property

204 Injury Index *(Most critical injury)*
1 ☐ None 2 ☐ Minor 3 ☐ Serious 4 ☐ Fatal

Injury Summary *(Enter only one digit per block)*	A Fatal	B Serious	C Minor	D None	E Total
205 First Pilot					
206 Co-pilot					
207 Dual Student					
208 Check Pilot					
209 Flight Engineer					
210 Cabin Attendants					
211 Other Crew					
212 Passengers					
213 TOTAL ABOARD					
214 Other Aircraft					
215 Other Ground					
216 GRAND TOTAL					

217 Classification
1 ☐ U.S. Registered Aircraft on U.S. Soil, Territories and Possessions, or International Waters
2 ☐ U.S. Registered Aircraft on Foreign Soil
3 ☐ U.S. Registered Aircraft operated by a Foreign Operator
4 ☐ Foreign Registered Aircraft on U.S. Soil, Territories or Possessions
5 ☐ Military Aircraft
6 ☐ Aircraft not Registered

Part Failure/Incorrect Part

220 Part Failure/Malfunction *(Multiple entry)*
1 ☐ None
2 ☐ Part/component #1
3 ☐ Part/component #2
4 ☐ Part/component #3
A Other _____

221 Incorrect Part *(Multiple entry)*
1 ☐ None
2 ☐ Part/component #1
3 ☐ Part/component #2
4 ☐ Part/component #3
A Other _____

	A Part/Component #1	B Part/Component #2	C Part/Component #3
222 Part Name			
223 ATA Code			
224 Manufacturer			
225 Mfg. Part #			
226 Mfg. Model #			
227 Serial #			
228 Part Condition			
229 Total Time			
230 TSO			
231 TSI			
232 Cycles Total			
233 Cycles Since Overhaul			
234 Cycles Since Inspection			
235 Service Difficulty Report or Malfunction/Defect Report Submitted	1 ☐ Yes 2 ☐ No	1 ☐ Yes 2 ☐ No	1 ☐ Yes 2 ☐ No
236 Bogus Part	1 ☐ Yes 2 ☐ No	1 ☐ Yes 2 ☐ No	1 ☐ Yes 2 ☐ No

National Transportation Safety Board

FACTUAL REPORT AVIATION

NTSB Accident/Incident Number

Supplement A
—Wreckage Documentation, Single and Twin Reciprocating Engine and Unpowered Aircraft

1 Engine #1 Serial No. _____
A Other

2 Engine #2 Serial No. _____
A Other

3 Supercharger Installed
1 ☐ Yes
2 ☐ No
A Other

4 Turbocharger Installed
1 ☐ Yes
2 ☐ No
A Other

5 Propeller Manufacturer _____
A Other

6 Propeller Model/Series _____
A Other

7 Propeller Type *(Multiple entry)*
1 ☐ Wood
2 ☐ Metal
3 ☐ Composite
4 ☐ Constant speed-controllable pitch
5 ☐ Ground Adjustable/variable pitch
6 ☐ Reversable
7 ☐ Full automatic feathering
8 ☐ Full manual feathering
A Other

8 Aircraft STOL Modification Installed
1 ☐ Yes
2 ☐ No
A Other

Landing Gear Positions *(If fixed gear, go to block 12)*

9 Nose/Tail
1 ☐ Up
2 ☐ Down
3 ☐ Intermediate
A Other

10 Left Main
1 ☐ Up
2 ☐ Down
3 ☐ Intermediate
A Other

11 Right Main
1 ☐ Up
2 ☐ Down
3 ☐ Intermediate
A Other

For Rotorcraft or Balloon accidents, go to block 20.

Control Surface Positions

12 Left Trailing Edge Flap
1 ☐ Up
A Extended _____ deg.
B Other

13 Right Trailing Edge Flap
1 ☐ Up
A Extended _____ deg.
B Other

14 Speed Brake
1 ☐ Not Installed
2 ☐ Stowed
3 ☐ Deployed
A Other

15 Spoiler
1 ☐ Not Installed
2 ☐ Stowed
3 ☐ Deployed
4 ☐ Deployed Asymetrically
A Other

Trim Tab Positions *(Multiple entry)*

16 Left Aileron
1 ☐ Not Installed
2 ☐ Neutral
3 ☐ Up
4 ☐ Down
A _____ deg.
B Other

17 Right Aileron
1 ☐ Not Installed
2 ☐ Neutral
3 ☐ Up
4 ☐ Down
A _____ deg.
B Other

18 Rudder
1 ☐ Not Installed
2 ☐ Neutral
3 ☐ Left
4 ☐ Right
A _____ deg.
B Other

19 Elevator/Stabilator/Ruddervator
1 ☐ Neutral
2 ☐ Up
3 ☐ Down
A _____ deg.
B Other

Cargo Restraint System

20 Cargo Restraint Installed *(Multiple entry)*
1 ☐ None *(Go to block 26)*
2 ☐ Cargo net
3 ☐ Straps/tie down
A Other

21 Cargo Restraint Used *(Multiple entry)*
1 ☐ None *(Go to block 26)*
2 ☐ Cargo net
3 ☐ Straps/tie down
A Other

22 Cargo Restraint Failed *(Multiple entry)*
1 ☐ None
2 ☐ Cargo net
3 ☐ Straps/tie down
A Other

Computed Weight and Balance Information- *Complete when weight and/or center of gravity limitations are exceeded on accident flight. (Otherwise go to block 32)*

Takeoff

26 Weight _____ Lbs.

27 Center of Gravity
A _____ % MAC or
B _____ Inches

28 CG Range *(Multiple entry)*
1 ☐ At takeoff weight
2 ☐ At max gross weight
A _____ % MAC to _____ % MAC or
B _____ Inches to _____ Inches

Accident

29 Weight _____ Lbs.

30 Center of Gravity
A _____ % MAC or
B _____ Inches

31 CG Range *(Multiple entry)*
1 ☐ At takeoff weight
2 ☐ At max gross weight
A _____ % MAC to _____ % MAC or
B _____ Inches to _____ Inches

32 Fuel On Board At Accident
1 ☐ Estimated
2 ☐ Verified
A Total gallons _____
B Other

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Supplement A—Wreckage Documentation, Single and Twin Reciprocating Engine and Unpowered Aircraft (continued)

Fuel Tanks	Fuel on Board at Accident			D Tank Construction				F Spillsafe Fittings			H Fuel Leakage/Rupture				
	A Gallons Estimated	B Gallons Verified	C Other	1 Wet Wing	2 Bladder	3 Metal	E Other	1 Yes	2 No	G Other	1 None	2 Line	3 Fitting	4 Tank	I Oth
33 Left Wing															
34 Right Wing															
35 Left Tip															
36 Right Tip															
37 Fuselage															
38 *(Specify)*															

41 Fuel Found In #1 Engine *(Multiple entry)*

1 ☐ None
2 ☐ Lines
3 ☐ Gascolator/strainer
4 ☐ Carburetor/fuel injector
5 ☐ Engine driven pump
6 ☐ Auxiliary fuel pump
7 ☐ Filter(s)
8 ☐ Selector valve
9 ☐ Fuel manifold/spider
10 ☐ Accumulator tank
A Other

42 Fuel Found In #2 Engine *(Multiple entry)*

1 ☐ None
2 ☐ Lines
3 ☐ Gascolator/strainer
4 ☐ Carburetor/fuel injector
5 ☐ Engine driven pump
6 ☐ Auxiliary fuel pump
7 ☐ Filter(s)
8 ☐ Selector valve
9 ☐ Fuel manifold/spider
10 ☐ Accumulator tank
A Other

43 Flight Controls, Evidence of Operational Failure or Malfunction *(Multiple entry)*

1 ☐ None
2 ☐ Pitch control
3 ☐ Roll control
4 ☐ Yaw control
A Other

44 Airframe/Structure, Evidence of In-Flight Separation/Failure *(Multiple entry)*

1 ☐ None
2 ☐ Helicopter *(Complete Supp. G)*
3 ☐ General disintegration
4 ☐ Left wing
5 ☐ Right wing
6 ☐ Left stab/elevator
7 ☐ Right stab/elevator
8 ☐ Vertical fin/rudder
9 ☐ Canard
10 ☐ Powerplant
11 ☐ Cabin/cargo door
A Other

45 Propeller, Evidence of In-Flight Separation/Failure

1 ☐ Yes
2 ☐ No
A Other

46 Powerplant, Evidence of In-Flight Mechanical Malfunction

1 ☐ Yes
2 ☐ No
A Other

47 Fuel, Evidence of Improper Grade or Contamination *(Multiple entry)*

1 ☐ None
2 ☐ Improper grade
3 ☐ Contamination
A Other

48 Oil, Evidence of Improper Grade or Contamination *(Multiple entry)*

1 ☐ None
2 ☐ Improper grade
3 ☐ Contamination
A Other

Emergency Locator Transmitter (ELT) Information

51 ELT Manufacturer

A Other

52 ELT Model No.

A Other

55 Preimpact ELT Location(s) *(Multiple entry)*

1 ☐ Cockpit
2 ☐ Cabin
3 ☐ Tailcone
4 ☐ Empennage
5 ☐ Raft
6 ☐ Survival Kit
A Other

53 ELT Battery Type

1 ☐ Alkaline
2 ☐ Cadmium
3 ☐ Nicad
4 ☐ Nickel
5 ☐ Lithium
A Other

54 ELT Battery Expiration Date *(Nos. for M, D, Y)*

A Other

56 ELT-Reason for Noneffectiveness/Failure *(Multiple entry)*

1 ☐ Operated effectively
2 ☐ Insufficient G's
3 ☐ Improper installation
4 ☐ Battery dead
5 ☐ Battery corroded
6 ☐ Battery installation incorrect
7 ☐ Incorrect battery
8 ☐ Fire damage
9 ☐ Impact damage
10 ☐ Antenna broken/disconnected
11 ☐ Water submersion
12 ☐ Unit not armed
13 ☐ Shielded by wreckage
14 ☐ Shielded by terrain
15 ☐ Internal failure
16 ☐ Test satisfactorily after accident
17 ☐ Signal direction altered by terrain
18 ☐ Packing device still installed
19 ☐ Remote switch off
A Other

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Supplement B—Cockpit Documentation, Single and Twin Reciprocating Engine and Unpowered Aircraft

1 **Cockpit Secured, Readings Not Pertinent** 1 ☐ Yes *(Go to block 3)*

2 **Cockpit/Instrument Panel Destroyed** 1 ☐ Yes *(Go to block 3)*

Cockpit Instrument Indications—*Enter direct in appropriate category*

Flight Instruments		Engine/System Instruments	
Item	Reading/Setting	Item	Reading/Setting

Comm/Nav Equipment		Miscellaneous	
Item	Frequency/Remark	Item	Remark

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Supplement B—Cockpit Documentation, Single and Twin Reciprocating Engine and Unpowered Aircraft (continued)

3 Navigational Equipment/Displays Installed *(Multiple entry)*
- 1 ☐ OMNI Head(s)
- 2 ☐ Glide slope
- 3 ☐ HSI
- 4 ☐ Flight director
- 5 ☐ RMI
- 6 ☐ RNAV
- 7 ☐ LORAN/Omega/INS
- 8 ☐ DME
- 9 ☐ ADF
- 10 ☐ Marker beacons
- A Other

4 Autopilot
- 1 ☐ Not installed
- 2 ☐ Engaged
- 3 ☐ Not engaged
- A Other

5 Digital Electronic/ Nav/Com Displays
- 1 ☐ Not installed
- 2 ☐ Installed
- A Other

6 Primary Altimeter Type
- 1 ☐ Counter-pointer
- 2 ☐ Drum-pointer
- 3 ☐ 3-pointer
- 4 ☐ 2-pointer
- A Other

7 Standby Altimeter Installed
- 1 ☐ Yes
- 2 ☐ No
- A Other

8 Radar Altimeter Installed
- 1 ☐ Yes
- 2 ☐ No
- A Other

9 Transponder
- 1 ☐ Not installed
- 2 ☐ Installed-not used
- 3 ☐ Installed-used
- 4 ☐ Installed-used-Altitude encoding
- A Other

10 Attitude Indicator Installed
- 1 ☐ Yes
- 2 ☐ No
- A Other

11 Attitude Indicator Power Source *(Multiple entry)*
- 1 ☐ Pressure/vacuum system
- 2 ☐ Pressure/vacuum system-with backup power source
- 3 ☐ Electrical
- 4 ☐ Standby indicator with alternate power source
- A Other

12 Type of Stall Warning Indicator
- 1 ☐ None
- 2 ☐ Visual/light
- 3 ☐ Visual/gauge
- 4 ☐ Aural
- 5 ☐ Stickshaker
- A Other

13 Weather Radar/Detection Equipment
- 1 ☐ Not installed
- 2 ☐ Installed-on
- 3 ☐ Installed-off
- 4 ☐ Installed, on/off unknown
- A Other

14 Type Weather Radar/Detection Equipment *(Multiple entry)*
1 ☐ Storm scope 2 ☐ Black and white radar 3 ☐ Color radar A Other

Electrical/System Switches

18 ☐ **Switches Destroyed/Inaccessible** *(Go to block 56)*
19 ☐ **Switch Positions Not Pertinent** *(Go to block 56)*

Switch/Item	1 Not Installed	2 On	3 Off	A Other	Pertinent Setting/Remark
20 Electrical Master					
21 Battery					
22 #1 Gen/Alternator					
23 #2 Gen/Alternator					
24 Inverter					
25 Avionics Master					
26 Pitot Heat					
29 Ice Detection					
30 Propeller Deice/Anti-Ice					
31 Windshield Deice					
32 Windshield Anti-Ice					
33 Airframe Deice					
36 Cabin Air/Fan					
37 Cabin Heater					
38 Air Conditioning					
39 Cabin Pressure Altitude					
40 Cabin Pressure Temperature					
41 Crew Oxygen					
42 Cabin/Passenger Oxygen					
46 Taxi Lights					
48 Landing Lights					
47 Rotating Beacon					

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Supplement B—Cockpit Documentation: Single and Twin Reciprocating Engine and Unpowered Aircraft (continued)

Electrical/System Switches (continued)

Switch/Item	1 Not Installed	2 On	3 Off	A Other	Pertinent Setting/Remark
48 Strobes					
49 Navigation Lights					
50 Instrument Panel Lights					
51 Cockpit/Storm Lights					
52 Cabin Lights					
53 ELT Remote					

Engine Controls-No. 1 Engine

58 ☐ Engine Control Positions Not Pertinent *(Go to block 65)*

57 Throttle Position
1 ☐ Not installed
2 ☐ Full forward
3 ☐ Midrange
4 ☐ Idle
A Other

58 Propeller
1 ☐ Not installed
2 ☐ Full increase (Low pitch)
3 ☐ Midrange
4 ☐ Full decrease (High pitch)
5 ☐ Feather
A Other

59 Mixture
1 ☐ Not installed
2 ☐ Full rich
3 ☐ Midrange
4 ☐ Idle cutoff
A Other

60 Carburetor Heat
1 ☐ Not installed
2 ☐ Full on
3 ☐ Partial
4 ☐ Off
A Other

61 Alternate Air
1 ☐ Not installed
2 ☐ Open
3 ☐ Closed
4 ☐ Midrange
A Other

62 Cowl Flaps
1 ☐ Not installed
2 ☐ Open
3 ☐ Closed
4 ☐ Midrange
A Other

63 Magneto Switch Position
1 ☐ Not installed
2 ☐ Both
3 ☐ Left
4 ☐ Right
5 ☐ Off
6 ☐ Start
A Other

64 Throttle Friction
1 ☐ Not installed
2 ☐ Tight
3 ☐ Loose
A Other

Engine Controls-No. 2 Engine

65 ☐ Engine Control Positions Not Pertinent *(Go to block 74)*

66 Throttle Position
1 ☐ Not installed
2 ☐ Full forward
3 ☐ Midrange
4 ☐ Idle
A Other

67 Propeller
1 ☐ Not installed
2 ☐ Full increase (Low pitch)
3 ☐ Midrange
4 ☐ Full decrease (High pitch)
5 ☐ Feather
A Other

68 Mixture
1 ☐ Not installed
2 ☐ Full rich
3 ☐ Midrange
4 ☐ Idle cutoff
A Other

69 Carburetor Heat
1 ☐ Not installed
2 ☐ Full on
3 ☐ Partial
4 ☐ Off
A Other

70 Alternate Air
1 ☐ Not installed
2 ☐ Open
3 ☐ Closed
4 ☐ Midrange
A Other

71 Cowl Flaps
1 ☐ Not installed
2 ☐ Open
3 ☐ Closed
4 ☐ Midrange
A Other

72 Magneto Switch Position
1 ☐ Not installed
2 ☐ Both
3 ☐ Left
4 ☐ Right
5 ☐ Off
6 ☐ Start
A Other

73 Throttle Friction
1 ☐ Not installed
2 ☐ Tight
3 ☐ Loose
A Other

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Supplement B—Cockpit Documentation, Single and Twin Reciprocating Engine and Unpowered Aircraft (continued)

Landing Gear Controls/Indicators, Flight Controls/Indicators, and Fuel Selectors/Pumps

74 Landing Gear Control
1 ☐ Not installed
2 ☐ Up
3 ☐ Down
4 ☐ Off
A Other

75 Landing Gear Indicator
1 ☐ Not installed
2 ☐ Up
3 ☐ Down
4 ☐ Transit/unsafe
A Other

76 Trailing Edge Flap System
1 ☐ Not installed
2 ☐ Manual
3 ☐ Electric
4 ☐ Hydraulic
A Other

77 Trailing Edge Flap Control
1 ☐ Not installed
2 ☐ Up
A Down _____ deg.
B Other

78 Trailing Edge Flap Indicator
1 ☐ Not installed
2 ☐ Up
A Down _____ deg.
B Other

79 Speed Brake Control
1 ☐ Not installed
2 ☐ Stowed
3 ☐ Deployed
A Other

80 Spoiler Control
1 ☐ Not installed
2 ☐ Stowed
3 ☐ Deployed
A Other

81 Dual Controls
1 ☐ Not installed
2 ☐ Installed
A Other

82 Throwover Control Yoke/Position
1 ☐ Not installed
2 ☐ Left
3 ☐ Right
4 ☐ Intermediate
A Other

83 Elev/Stab Trim Control *(Multiple entry)*
1 ☐ Not installed
2 ☐ Manual
3 ☐ Electric
A Other

84 Elev/Stab Trim Indicator
1 ☐ Not installed
2 ☐ Up
3 ☐ Down
4 ☐ Neutral
A Other

85 Aileron Trim Control *(Multiple entry)*
1 ☐ Not installed
2 ☐ Manual
3 ☐ Electric
A Other

86 Aileron Trim Indicator
1 ☐ Not installed
2 ☐ Left
3 ☐ Right
4 ☐ Neutral
A Other

87 Rudder Trim Indicator
1 ☐ Not installed
2 ☐ Left
3 ☐ Right
4 ☐ Neutral
A Other

88 Fuel Selector Position(s) *(Multiple entry)*
1 ☐ Left main
2 ☐ Right main
3 ☐ Both
4 ☐ Left auxiliary
5 ☐ Right auxiliary
6 ☐ Center
7 ☐ Forward
8 ☐ Aft
9 ☐ External tank
10 ☐ Between tanks
11 ☐ X-feed left to right
12 ☐ X-feed right to left
13 ☐ On-engine #1
14 ☐ Off-engine #1
15 ☐ On-engine #2
16 ☐ Off-engine #2
A Other

89 Fuel Boost Pump, Engine #1
1 ☐ Not installed
2 ☐ On
3 ☐ High
4 ☐ Low
5 ☐ Off
A Other

90 Fuel Boost Pump, Engine #2
1 ☐ Not installed
2 ☐ On
3 ☐ High
4 ☐ Low
5 ☐ Off
A Other

91 Fuel Transfer Pump
1 ☐ Not installed
2 ☐ Off
A On (____ tank to ____ tank)
B Other

92 Primer, Engine #1
1 ☐ Not installed
2 ☐ Locked
3 ☐ Unlocked
A Other

93 Primer Engine #2
1 ☐ Not installed
2 ☐ Locked
3 ☐ Unlocked
A Other

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NTSB Accident/Incident Number

Supplement C—Wreckage Documentation: Multi-(3 or more) Reciprocating Engine and Turbine Powered Aircraft

Landing Gear Position

1 Nose/Tail	2 Left Main	3 Right Main	4 Body Gear
1 ☐ Up	1 ☐ Up	1 ☐ Up	1 ☐ Not installed
2 ☐ Down	2 ☐ Down	2 ☐ Down	2 ☐ Up
3 ☐ Intermediate	3 ☐ Intermediate	3 ☐ Intermediate	3 ☐ Down
A Other	A Other	A Other	4 ☐ Intermediate
			A Other

Landing Gear Damage

	A Impact			B Fire		
	1 Destroyed	2 Substantial	3 Minor/None	1 Destroyed	2 Substantial	3 Minor/None
5 Nose/tail						
6 Left/main						
7 Right/main						

Trailing Edge Flap Positions

8 Left Inboard	9 Left Outboard	10 Right Inboard	11 Right Outboard
1 ☐ Up	1 ☐ Up	1 ☐ Up	1 ☐ Up
A Down _____ deg.	A Down _____ deg.	A Down _____ deg.	A Down _____ deg.
B Other	B Other	B Other	B Other

Leading Edge Flap Positions

12 ☐ Not Installed *(Go to block 17)*

13 Left Inboard	14 Left Outboard	15 Right Inboard	16 Right Outboard
1 ☐ Up	1 ☐ Up	1 ☐ Up	1 ☐ Up
A Down _____ deg.	A Down _____ deg.	A Down _____ deg.	A Down _____ deg.
B Other	B Other	B Other	B Other

Leading Edge Slat Position

17 ☐ Not Installed *(Go to block 22)*

18 Left Inboard	19 Left Outboard	20 Right Inboard	21 Right Outboard
1 ☐ Up	1 ☐ Up	1 ☐ Up	1 ☐ Up
A Down _____ deg.	A Down _____ deg.	A Down _____ deg.	A Down _____ deg.
B Other	B Other	B Other	B Other

Spoiler Positions

22 ☐ Not Installed *(Go to block 27)*

23 Flight Spoilers-Left	24 Flight Spoilers-Right	25 Ground Spoilers-Left	26 Ground Spoilers-Right
1 ☐ Stowed	1 ☐ Stowed	1 ☐ Stowed	1 ☐ Stowed
2 ☐ Deployed	2 ☐ Deployed	2 ☐ Deployed	2 ☐ Deployed
A Other	A Other	A Other	A Other

Trim Tab Positions *(Multiple entry)*

27 ☐ Not Installed *(Go to block 33)*

28 Left Aileron	29 Right Aileron	30 Upper Rudder	31 Lower Rudder	32 Elevator/Stab.
1 ☐ Not installed	1 ☐ Not installed	1 ☐ Not installed	1 ☐ Not installed	1 ☐ Not installed
2 ☐ Neutral	2 ☐ Neutral	2 ☐ Neutral	2 ☐ Neutral	2 ☐ Neutral
3 ☐ Up	3 ☐ Up	3 ☐ Left	3 ☐ Left	3 ☐ Up
4 ☐ Down	4 ☐ Down	4 ☐ Right	4 ☐ Right	4 ☐ Down
A _____ deg.	A _____ deg.	A _____ deg.	A _____ deg.	A _____ deg.
B Other	B Other	B Other	B Other	B Other

Cargo Restraint System(s) *(Multiple entry for each block)*

33 Cargo Restraint Installed	34 Cargo Restraint Used	35 Cargo Restraint Failed
1 ☐ None *(Go to block 36)*	1 ☐ None *(Go to block 36)*	1 ☐ None
2 ☐ Cargo net	2 ☐ Cargo net	2 ☐ Cargo net
3 ☐ Straps/tie down	3 ☐ Straps/tie down	3 ☐ Straps/tie down
A Other	A Other	A Other

36 Airframe/Structure, Evidence of In-flight Separation/Failure *(Multiple entry)*

1 ☐ None	5 ☐ Right wing	9 ☐ Canard	13 ☐ Cabin door(s)
2 ☐ Helicopter *(Complete Supplement G)*	6 ☐ Left stab/elevator	10 ☐ Tail cone	14 ☐ Cargo door(s)
3 ☐ General disintegration	7 ☐ Right stab/elevator	11 ☐ Powerplant	A Specify _____
4 ☐ Left wing	8 ☐ Vertical fin/rudder	12 ☐ Powerplant nacelle	B Other

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Supplement C Wreckage Documentation Multi-(3 or more) Reciprocating Engine and Turbine Powered Aircraft (continued)

39 Flight Control System, Evidence of Operational Failure or Malfunction *(Multiple entry)*

1 ☐ None
2 ☐ Pitch Control
3 ☐ Roll control
4 ☐ Yaw control
A Specify _____
B Other

40 Aircraft STOL Modification Installed

1 ☐ Yes
2 ☐ No
A Other

Computed Weight and Balance Information— *Complete when weight and/or center of gravity limitations are exceeded. Otherwise, go to block 51.*

Takeoff

45 Weight
_____ Lbs.

46 Center of Gravity
A _____ % MAC or
B _____ Inches

47 CG Range *(Multiple entry)*
1 ☐ At takeoff weight
2 ☐ At max gross weight
A _____ % MAC to _____ MAC or
B _____ Inches to _____ Inches

Accident

48 Weight
_____ Lbs.

49 Center of Gravity
A _____ % MAC or
B _____ Inches

50 CG Range *(Multiple entry)*
1 ☐ At takeoff weight
2 ☐ At accident weight
A _____ % MAC to _____ MAC or
B _____ Inches to _____ Inches

51 Fuel On Board at Accident
1 ☐ Estimated
2 ☐ Verified
A _____ Gallons
B _____ Pounds
C Other

Fuel Tanks	Fuel On Board at Accident			D Tank Construction				F Spillsafe Fittings			H Fuel Leakage/Rupture				
	A Gallons Estimated	B Gallons Verified	C Other	1 Wet Wing	2 Bladder	3 Metal	E Other	1 Yes	2 No	G Other	1 None	2 Line	3 Fitting	4 Tank	I Other
52 Left Wing															
53 Right Wing															
54 Left Tip															
55 Right Tip															
56 Fuselage															
57 *(Specify)* _____															

Engine/Propeller Historical Information

Engines	A Engine #1	B Engine #2	C Engine #3	D Engine #4	E Other
60 Serial Number					
61 Hours, Total					
62 Date, Last Overhaul *(Nos. for M. D. Y)*					
63 Hours, Since Last Overhaul					
64 Date, Last Inspection *(Nos. for M. D. Y)*					
65 Hours, Since Last Inspection					

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Supplement C—Wreckage Documentation. Multi-(3 or more) Reciprocating Engine and Turbine-Powered Aircraft (continued)

Propellers 68 Not installed (Go to block 85)	A Engine #1	B Engine #2	C Engine #3	D Engine #4	E Other
69 Propeller Manufacturer					
70 Propeller Model/Series Number					
71 Hours, Total					
72 Hours, Since Overhaul					
73 Date, Last Overhaul (Nos. for M. D. Y)					
74 Hours, Since Last Inspection					
75 Date, Last Inspection (Nos. for M. D. Y)					

78 Propeller Type *(Multiple entry)*

1 ☐ None installed
2 ☐ Metal
3 ☐ Composite
4 ☐ Constant speed-controllable pitch
5 ☐ Reversible
6 ☐ Full automatic feathering
7 ☐ Full manual feathering
A Other

79 Engine Supercharger Installed

1 ☐ Yes
2 ☐ No
A Other

80 Engine Turbocharger Installed

1 ☐ Yes
2 ☐ No
A Other

Firewall Valve Shutoff Position — 85 ☐ **Not installed** *(Go to block 90)*

86 Engine #1

1 ☐ Not installed
2 ☐ Open
3 ☐ Closed
A Other

87 Engine #2

1 ☐ Not installed
2 ☐ Open
3 ☐ Closed
A Other

88 Engine #3

1 ☐ Not installed
2 ☐ Open
3 ☐ Closed
A Other

89 Engine #4

1 ☐ Not installed
2 ☐ Open
3 ☐ Closed
A Other

Thrust Reverser Position — 90 ☐ **Not installed** *(Go to block 97)*

	1 Open	2 Closed	3 Intermediate	A Other
91 #1 Engine				
92 #2 Engine				
93 #3 Engine				
94 #4 Engine				

97 Fuel Found In #1 Engine *(Multiple entry)*

1 ☐ None
2 ☐ Lines
3 ☐ Strainer
4 ☐ Fuel control
5 ☐ Carburetor/fuel injector
6 ☐ Engine driven pump
7 ☐ Aux fuel pump
8 ☐ Filter(s)
9 ☐ Selector valve
10 ☐ Fuel manifold/spider
A Other

98 Fuel Found In #2 Engine *(Multiple entry)*

1 ☐ None
2 ☐ Lines
3 ☐ Strainer
4 ☐ Fuel control
5 ☐ Carburetor/fuel injector
6 ☐ Engine driven pump
7 ☐ Aux fuel pump
8 ☐ Filter(s)
9 ☐ Selector valve
10 ☐ Fuel manifold/spider
A Other

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Supplement C — Wreckage Documentation, Multi-(3 or more) Reciprocating Engine and Turbine-Powered Aircraft (continued)

99 Fuel Found In #3 Engine *(Multiple entry)*

1 ☐ None
2 ☐ Lines
3 ☐ Strainer
4 ☐ Fuel control
5 ☐ Carburetor/fuel injector
6 ☐ Engine driven pump
7 ☐ Aux fuel pump
8 ☐ Filter(s)
9 ☐ Selector valve
10 ☐ Fuel manifold/spider
A Other

100 Fuel Found In #4 Engine *(Multiple entry)*

1 ☐ None
2 ☐ Lines
3 ☐ Strainer
4 ☐ Fuel control
5 ☐ Carburetor/fuel injector
6 ☐ Engine driven pump
7 ☐ Aux fuel pump
8 ☐ Filter(s)
9 ☐ Selector valve
10 ☐ Fuel manifold/spider
A Other

101 Fuel Samples Analyzed

1 ☐ Yes
2 ☐ No
A Other

102 Fuel, Evidence of Improper Grade or Contamination *(Multiple entry)*

1 ☐ None
2 ☐ Improper Grade
3 ☐ Contamination
A Other

103 Lube Oil Analyzed

1 ☐ Yes
2 ☐ No
A Other

104 Lube Oil, Evidence of Improper Grade or Contamination *(Multiple entry)*

1 ☐ None
2 ☐ Improper Grade
3 ☐ Contamination
A Other

105 Engine In-flight Failure *(Multiple entry)*

1 ☐ No
2 ☐ Yes
3 ☐ Rotational
4 ☐ Explosion
A Other

106 Engine Failure Position *(Multiple entry)*

1 ☐ #1
2 ☐ #2
3 ☐ #3
4 ☐ #4
A Other

107 Failure Contained

1 ☐ Yes
2 ☐ No
A Other

108 Engine In-flight Fire *(Multiple entry)*

1 ☐ None
2 ☐ #1 Engine
3 ☐ #2 Engine
4 ☐ #3 Engine
5 ☐ #4 Engine
A Other

ELT (Emergency Locator Transmitter) Information

112 Preimpact Location of ELT's *(Multiple entry)* (Enter number by location)

A Cockpit _____ D Raft _____
B Cabin _____ E Survival kit _____
C Empennage _____ F Other _____

113 Reason(s) for ELT Failure/Noneffectiveness *(Enter codes from list below by ELT location)* *(Multiple entry)*

A Cockpit _____ C Empennage _____ E Survival kit _____
B Cabin _____ D Raft _____ F Other _____

Reason(s) for Noneffectiveness/Failure *(ELT choices for block 113)*

01 Insufficient G's
02 Improper installation
03 Battery corroded
05 Battery installed incorrectly
06 Incorrect battery
07 Fire damage
08 Impact damage
09 Antenna broken/disconnected
10 Water submersion
11 Unit not armed
12 Shielded by wreckage
13 Shielded by terrain
14 Internal failure
15 Tested satisfactorily after accident
16 Signal direction altered by terrain
17 Packing device still installed
18 Remote switch off

114 ELT Manufacturer, Fixed ELT's

_____
A Other

115 ELT Model No., Fixed ELT's

_____
A Other

116 ELT Battery Type, Fixed ELT's

1 ☐ Alkaline
2 ☐ Cadmium
3 ☐ Ni/Cad
4 ☐ Nickel
5 ☐ Lithium
A Other

117 Battery Expiration Date, Fixed ELT's *(Nos. for M, D, Y)*

_____
A Other

118 ELT Manufacturer, Raft ELT's

_____
A Other

119 ELT Model No., Raft ELT's

_____
A Other

120 ELT Battery Type, Raft ELT's

1 ☐ Alkaline
2 ☐ Cadmium
3 ☐ Ni/Cad
4 ☐ Nickel
5 ☐ Lithium
A Other

121 Battery Expiration Date, Raft ELT's *(Nos. for M, D, Y)*

_____
A Other

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Supplement D—Cockpit Documentation, Multi (3 or more) Reciprocating Engine and Turbine Powered Aircraft

1 **Cockpit Secured, Readings Not Pertinent** ☐ Yes *(Go to block 3)*

2 **Cockpit/Instrument Panel Destroyed** ☐ Yes *(Go to block 3)*

Cockpit Instrument Indications— *Enter direct in appropriate category*

Flight Instruments		Engine Instruments	
Item	**Reading/Setting**	**Item**	**Reading/Setting**

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Supplement D — Cockpit Documentation, Multi (3 or more) Reciprocating Engine and Turbine Powered Aircraft (continued)

Cockpit Instrument Indications (continued)— *Enter direct in appropriate category*

Aircraft System Instrumentation		Communications and Navigation Equipment	
Item	Reading/Setting	Item	Frequency/Setting/Reading

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Supplement D — Cockpit Documentation: Multi (3 or more) Reciprocating Engine and Turbine Powered Aircraft (continued)

Aircraft Equipment

3 Aircraft Certificated For Two-Pilot Operation
1 ☐ Yes
2 ☐ No
A Other

4 Autopilot
1 ☐ Not installed
2 ☐ Engaged
3 ☐ Not engaged
A Other

5 Digital Electronic Nav/Comm Displays
1 ☐ Not installed
2 ☐ Installed
A Other

6 Heads Up Display
1 ☐ Not installed
2 ☐ In use
3 ☐ Not in use
A Other

7 Nav Equipment/Displays Installed *(Multiple entry)*
1 ☐ OMNI heads
2 ☐ Glide slope
3 ☐ HSI
4 ☐ Flight director
5 ☐ RMI
6 ☐ RNAV
7 ☐ INS
8 ☐ VLF/Omega
9 ☐ LORAN
10 ☐ DME
11 ☐ ADF
12 ☐ Marker beacons
A Other

8 Left Panel Altimeter Type
1 ☐ Not installed
2 ☐ Counter/pointer
3 ☐ Drum/pointer
4 ☐ 3-pointer
5 ☐ 2-pointer
A Other

9 Right Panel Altimeter Type
1 ☐ Not installed
2 ☐ Counter/pointer
3 ☐ Drum/pointer
4 ☐ 3-pointer
5 ☐ 2-pointer
A Other

10 Standby Altimeter
1 ☐ Not installed
2 ☐ Installed
A Other

11 Radar Altimeter
1 ☐ Not installed
2 ☐ Installed
A Other

12 Angle of Attack Indicator
1 ☐ Not installed
2 ☐ Installed
A Other

13 Attitude Indicators Installed and Operating *(Multiple entry)*
1 ☐ Left position
2 ☐ Right position
3 ☐ None operating
A Other

14 Primary Attitude Indicator Power Source *(Multiple entry)*
1 ☐ Pressure/vacuum system
2 ☐ Pressure/vacuum system with backup power source
3 ☐ Electrical
4 ☐ Standby indicator with alternate power source
A Other

15 Type of Stall Warning Indicator *(Multiple entry)*
1 ☐ Visual/light
2 ☐ Visual/gauge
3 ☐ Aural
4 ☐ Stickpusher
5 ☐ Stickshaker
A Other

16 Stall Warning System Capable of Operation
1 ☐ Yes
2 ☐ No
3 ☐ Partial
A Other

17 Transponder
1 ☐ Not installed
2 ☐ Installed-not used
3 ☐ Installed-used
4 ☐ Installed-used-altimeter encoding
A Other

18 Weather Radar/Detection Equipment
1 ☐ Not installed
2 ☐ Installed-on
3 ☐ Installed-off
4 ☐ Installed, on/off unknown
A Other

19 Weather Radar
1 ☐ Operative
2 ☐ Inoperative
A Other

20 Type Weather Radar/Detection Equipment
1 ☐ Storm scope
2 ☐ Black and white radar
3 ☐ Color radar
A Other

Electric/System Switches

24 ☐ **Switches Destroyed/Inaccessible** *(Go to block 76)*
25 ☐ **Switch Positions Not Pertinent** *(Go to block 76)*

Switch/Item	1 Not Installed	2 On	3 Off	A Other	Pertinent Setting/Remark
26 Electrical Master					
27 Battery					
28 APU					
29 #1 Gen/Alternator					
30 #2 Gen/Alternator					
31 #3 Gen/Alternator					
32 #4 Gen/Alternator					
33 Inverter					
34 Avionics Master					
37 Pitot Heat					
38 Engine/Nacelle Anti-Ice					
39 Engine Deice					
40 Ice Detection					

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Supplement D — Cockpit Documentation, Multi (3 or more) Reciprocating Engine and Turbine Powered Aircraft (continued)

Electric/System Switches (continued)

Switch/Item	1 Not Installed	2 On	3 Off	A Other (Enter code)	Pertinent Setting/Remark
41 Propeller Deice/Anti-Ice					
42 Windshield Deice					
43 Windshield Anti—Ice					
44 Airframe Deice					
47 Cockpit Air/Fan					
48 Cabin Air/Fan					
49 Cabin Heater					
50 Air Conditioning					
51 Cabin Pressure Altitude					
52 Cabin Pressure Temperature					
53 Crew Oxygen					
54 Cabin/Passenger Oxygen					
57 Taxi Lights					
58 Landing Lights					
59 Rotating Beacon					
60 Strobes					
61 Navigation Lights					
62 Instrument Panel Lights					
63 Cockpit/Storm Lights					
64 Cabin Lights					
65 Seat Belt Light					
66 No Smoking Light					
67 ELT Remote					
70 Antiskid System					
71 Ground Proximity Warning					
72 Altitude Alert					
73 Collision Avoidance System					

Engine Controls—No. 1 Engine

76 ☐ Engine Control Positions Not Pertinent *(Go to No. 2 Engine)*

77 Throttle	78 Condition/Power	79 Mixture	80 Propeller	81 Carburetor Heat	82 Alternate Air
1 ☐ Not installed	1 ☐ Not installed	1 ☐ Not installed	1 ☐ Not installed	1 ☐ Not installed	1 ☐ Not installed
2 ☐ Full forward	2 ☐ Full forward	2 ☐ Full rich	2 ☐ Power range	2 ☐ Full on	2 ☐ Open
3 ☐ Midrange	3 ☐ Midrange	3 ☐ Midrange	3 ☐ Reverse	3 ☐ Partial	3 ☐ Closed
4 ☐ Idle	4 ☐ Idle	4 ☐ Idle cutoff	4 ☐ Feather	4 ☐ Off	4 ☐ Midrange
A Other	5 ☐ Reverse	5 ☐ Auto	5 ☐ Beta	A Other	A Other
	6 ☐ Off	A Other	A Other		
	A Other				

83 Cowl Flaps	84 Magneto Switch Position	85 Auto Ignition	86 Auto Feather	87 Throttle Quadrant Friction
1 ☐ Not installed	1 ☐ Not installed	1 ☐ Not installed	1 ☐ Not installed	1 ☐ Not installed
2 ☐ Open	2 ☐ Both	2 ☐ On	2 ☐ On	2 ☐ Tight
3 ☐ Closed	3 ☐ Left	3 ☐ Off	3 ☐ Off	3 ☐ Loose
4 ☐ Midrange	4 ☐ Right	A Other	A Other	A Other
A Other	5 ☐ Off			
	A Other			

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Supplement D — Cockpit Documentation, Multi (3 or more) Reciprocating Engine and Turbine Powered Aircraft (continued)

Engine Controls—No. 2 Engine

88 ☐ Engine Control Positions Not Pertinent *(Go to No. 3 Engine)*

89 Throttle
1 ☐ Not installed
2 ☐ Full forward
3 ☐ Midrange
4 ☐ Idle
A Other

90 Condition/Power
1 ☐ Not installed
2 ☐ Full forward
3 ☐ Midrange
4 ☐ Idle
5 ☐ Reverse
6 ☐ Off
A Other

91 Mixture
1 ☐ Not installed
2 ☐ Full rich
3 ☐ Midrange
4 ☐ Idle cutoff
5 ☐ Auto
A Other

92 Propeller
1 ☐ Not installed
2 ☐ Power range
3 ☐ Reverse
4 ☐ Feather
5 ☐ Beta
A Other

93 Carburetor Heat
1 ☐ Not installed
2 ☐ Full on
3 ☐ Partial
4 ☐ Off
A Other

94 Alternate Air
1 ☐ Not installed
2 ☐ Open
3 ☐ Closed
4 ☐ Midrange
A Other

95 Cowl Flaps
1 ☐ Not installed
2 ☐ Open
3 ☐ Closed
4 ☐ Midrange
A Other

96 Magneto Switch Position
1 ☐ Not installed
2 ☐ Both
3 ☐ Left
4 ☐ Right
5 ☐ Off
A Other

97 Auto Ignition
1 ☐ Not installed
2 ☐ On
3 ☐ Off
A Other

98 Auto Feather
1 ☐ Not installed
2 ☐ On
3 ☐ Off
A Other

99 Throttle Quadrant Friction
1 ☐ Not installed
2 ☐ Tight
3 ☐ Loose
A Other

Engine Controls—No. 3 Engine

100 ☐ Engine Control Positions Not Pertinent *(Go to No. 4 Engine)*

101 Throttle
1 ☐ Not installed
2 ☐ Full forward
3 ☐ Midrange
4 ☐ Idle
A Other

102 Condition/Power
1 ☐ Not installed
2 ☐ Full forward
3 ☐ Midrange
4 ☐ Idle
5 ☐ Reverse
6 ☐ Off
A Other

103 Mixture
1 ☐ Not installed
2 ☐ Full rich
3 ☐ Midrange
4 ☐ Idle cutoff
5 ☐ Auto
A Other

104 Propeller
1 ☐ Not installed
2 ☐ Power range
3 ☐ Reverse
4 ☐ Feather
5 ☐ Beta
A Other

105 Carburetor Heat
1 ☐ Not installed
2 ☐ Full on
3 ☐ Partial
4 ☐ Off
A Other

106 Alternate Air
1 ☐ Not installed
2 ☐ Open
3 ☐ Closed
4 ☐ Midrange
A Other

107 Cowl Flaps
1 ☐ Not installed
2 ☐ Open
3 ☐ Closed
4 ☐ Midrange
A Other

108 Magneto Switch Position
1 ☐ Not installed
2 ☐ Both
3 ☐ Left
4 ☐ Right
5 ☐ Off
A Other

109 Auto Ignition
1 ☐ Not installed
2 ☐ On
3 ☐ Off
A Other

110 Auto Feather
1 ☐ Not installed
2 ☐ On
3 ☐ Off
A Other

111 Throttle Quadrant Friction
1 ☐ Not installed
2 ☐ Tight
3 ☐ Loose
A Other

Engine Controls—No. 4 Engine

112 ☐ Engine Control Positions Not Pertinent *(Go to block 124)*

113 Throttle
1 ☐ Not installed
2 ☐ Full forward
3 ☐ Midrange
4 ☐ Idle
A Other

114 Condition/Power
1 ☐ Not installed
2 ☐ Full forward
3 ☐ Midrange
4 ☐ Idle
5 ☐ Reverse
6 ☐ Off
A Other

115 Mixture
1 ☐ Not installed
2 ☐ Full rich
3 ☐ Midrange
4 ☐ Idle cutoff
5 ☐ Auto
A Other

116 Propeller
1 ☐ Not installed
2 ☐ Power range
3 ☐ Reverse
4 ☐ Feather
5 ☐ Beta
A Other

117 Carburetor Heat
1 ☐ Not installed
2 ☐ Full on
3 ☐ Partial
4 ☐ Off
A Other

118 Alternate Air
1 ☐ Not installed
2 ☐ Open
3 ☐ Closed
4 ☐ Midrange
A Other

119 Cowl Flaps
1 ☐ Not installed
2 ☐ Open
3 ☐ Closed
4 ☐ Midrange
A Other

120 Magneto Switch Position
1 ☐ Not installed
2 ☐ Both
3 ☐ Left
4 ☐ Right
5 ☐ Off
A Other

121 Auto Ignition
1 ☐ Not installed
2 ☐ On
3 ☐ Off
A Other

122 Auto Feather
1 ☐ Not installed
2 ☐ On
3 ☐ Off
A Other

123 Throttle Quadrant Friction
1 ☐ Not installed
2 ☐ Tight
3 ☐ Loose
A Other

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Supplement D — Cockpit Documentation, Multi (3 or more) Reciprocating Engine and Turbine Powered Aircraft (continued)

Landing Gear Controls/Indicators and Flight Control/Indicators

124 Landing Gear Control
1 ☐ Not installed
2 ☐ Up
3 ☐ Down
4 ☐ Neutral/off
A Other

125 Landing Gear Indicator
1 ☐ Not installed
2 ☐ Up
3 ☐ Down
4 ☐ Transit/unsafe
A Other

126 Trailing Edge Flap Control
1 ☐ Not installed
2 ☐ Up
A Down _____ deg.
B Other

127 Trailing Edge Flap Indicator
1 ☐ Not installed
2 ☐ Up
A Down _____ deg.
B Other

128 Leading Edge Flap Control
1 ☐ Not installed
2 ☐ Up
A Down _____ deg.
B Other

129 Leading Edge Flap Indicator
1 ☐ Not installed
2 ☐ Up
A Down _____ deg.
B Other

130 Leading Edge Slat Control
1 ☐ Not installed
2 ☐ Up
A Down _____ deg.
B Other

131 Leading Edge Slat Indicator
1 ☐ Not installed
2 ☐ Up
A Down _____ deg.
B Other

132 Flight Spoiler Control
1 ☐ Not installed
2 ☐ Stowed
3 ☐ Deployed
A Other

133 Ground Spoiler Control
1 ☐ Not installed
2 ☐ Stowed
3 ☐ Armed
4 ☐ Deployed
A Other

134 Drag Chute
1 ☐ Not installed
2 ☐ Stowed
3 ☐ Deployed
A Other

135 Autothrottle
1 ☐ Not installed
2 ☐ Engaged
3 ☐ Not engaged
A Other

136 Dual Controls
1 ☐ Not installed
2 ☐ Installed
A Other

137 Elevator/Stab Trim Control
1 ☐ Not installed
2 ☐ Up
3 ☐ Down
4 ☐ Neutral
A Other

138 Aileron Trim Indicator
1 ☐ Not installed
2 ☐ Left
3 ☐ Right
4 ☐ Neutral
A Other

139 Upper Rudder Trim Indicator
1 ☐ Not installed
2 ☐ Left
3 ☐ Right
4 ☐ Neutral
A Other

140 Lower Rudder Trim Indicator
1 ☐ Not installed
2 ☐ Left
3 ☐ Right
4 ☐ Neutral
A Other

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Supplement E — Second Pilot Information

1 Second Pilot Responsibilities
1 ☐ Copilot 2 ☐ Dual student 3 ☐ Safety pilot 4 ☐ Check pilot 5 ☐ None (Pilot-Rated Passenger) A Other

2 Name *(Last, First, Initial)* _____ A Other

3 Pilot Certificate No. _____ A Other

4 Street Address _____ A Other

5 City _____ A Other

6 State

7 Date of Birth *(Nos. for M, D, Y)* _____ A Other

8 Age _____ A Other

9 Sex
1 ☐ Male
2 ☐ Female

10 Seat Occupied *(Multiple entry)*
1 ☐ Left 4 ☐ Front
2 ☐ Right 5 ☐ Rear
3 ☐ Center A Other

11 Principal Profession
1 ☐ Pilot-civilian 4 ☐ Aircraft mechanic 7 ☐ Doctor/dentist 10 ☐ Clergy 13 ☐ Farmer/Rancher
2 ☐ Pilot-military 5 ☐ Business 8 ☐ Police 11 ☐ Teacher 14 ☐ Retired
3 ☐ Other-military 6 ☐ Lawyer 9 ☐ Student 12 ☐ Engineer A Other

12 Certificate(s) *(Multiple entry)*
1 ☐ Student 7 ☐ Military
2 ☐ Private 8 ☐ None
3 ☐ Commercial 9 ☐ Foreign
4 ☐ Airline Transport A Other
5 ☐ Flight Instructor
6 ☐ Flight Engineer

13 Ratings—Airplane *(Multiple entry)*
1 ☐ None
2 ☐ Single engine land
3 ☐ Multiengine land
4 ☐ Single engine sea
5 ☐ Multiengine sea

14 Rotorcraft/Glider/LTA *(Multiple entry)*
1 ☐ None
2 ☐ Helicopter
3 ☐ Gyroplane
4 ☐ Airship
5 ☐ Free balloon
6 ☐ Glider

15 Instrument Rating *(Multiple entry)*
1 ☐ None
2 ☐ Airplane
3 ☐ Helicopter

16 Instructor Rating(s) *(Multiple entry)*
1 ☐ None 5 ☐ Gyroplane
2 ☐ Airplane SE 6 ☐ Glider
3 ☐ Airplane ME 7 ☐ Instrument airplane
4 ☐ Helicopter 8 ☐ Instrument helicopter

17 Ground Instructor
1 ☐ Basic
2 ☐ Advanced
3 ☐ Instrument
4 ☐ None

18 Type Rating/Endorsement This Aircraft
1 ☐ Yes
2 ☐ No *(Go to block 20)*
A Other

19 Months Since Check/Endorsement This Aircraft _____ A Other

20 Biennial Flight Review
1 ☐ Yes
2 ☐ No
A Other

21 Months Since Last BFR _____ Months A Other

22 BFR *(or equivalent)* **Aircraft Make/Model**
A Make _____
B Model _____
C Other

23 Medical Certificate
1 ☐ None
2 ☐ Class 1
3 ☐ Class 2
4 ☐ Class 3
A Other

24 Medical Certificate Validity
1 ☐ Valid medical-no waivers/limitations 5 ☐ No medical certificate
2 ☐ Valid medical-with waivers/limitations A Other
3 ☐ Non valid medical for this flight
4 ☐ Expired

25 Date of Last Medical *(Nos. for D, M, Y)* _____ A Other

26 Medical Limitation
1 ☐ None
2 ☐ Vision
A Specify _____
B Other

27 Medical Waiver
1 ☐ None
2 ☐ Vision
3 ☐ Hearing
A Specify _____
B Other

28 Statement of Demonstrated Ability
1 ☐ Yes
2 ☐ No
A Other

29 Correcting Lenses *(Multiple entry)*
1 ☐ Not required
2 ☐ Required to be in possession
3 ☐ Required, not in possession
4 ☐ Required to be worn
5 ☐ Required, not worn
6 ☐ Worn at time of accident
A Other

30 Source of Pilot Time
1 ☐ Pilot Log 3 ☐ FAA 5 ☐ Investigator's Estimate 7 ☐ Other Person
2 ☐ Company 4 ☐ Pilot/Operator Report 6 ☐ Relative A Other

National Transportation Safety Board

FACTUAL REPORT AVIATION

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Supplement E — Second Pilot Information (continued)

Flight Time	A All A/C	B This Make & Model	C Airplane Single Engine	D Airplane Multi Engine	E Night	F Instrument Actual	G Instrument Simulated	H Rotorcraft	I Glider	J Lighter Than Air	K Other Code
35 Total Time											
36 Pilot in Command (PIC)											
37 Instructor											
38 This Make/Model											
39 Last 90 Days											
40 Last 30 Days											
41 Last 24 Hours											

42 Landings—Last 90 Days— All Aircraft—Day
A Other

43 Landings—Last 90 Days—All Aircraft—Night
A Other

44 Landings—Last 90 Days—This Make/Model—Day
A Other

45 Landings—Last 90 Days—This Make/Model—Night
A Other

46 Seatbelt Available
1 ☐ Yes
2 ☐ No
A Other

47 Seatbelt Used
1 ☐ Yes
2 ☐ No
A Other

48 Shoulder Harness Available
1 ☐ Yes
2 ☐ No
A Other

49 Shoulder Harness Used
1 ☐ Yes
2 ☐ No
A Other

50 Autopsy Performed — *(This Pilot)*
1 ☐ Yes
2 ☐ No
A Other

51 Toxicology Performed — *(This Pilot)*
1 ☐ Yes
2 ☐ No
A Other

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FACTUAL REPORT
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Supplement F Pilot Second Pilot Training and Proficiency

Pilot in Command Information: 1 ☐ *If pertinent certificate or rating obtained more than 2 years previous to accident, mark "X" here and proceed to block 10.*

2 Certificate and/or Rating For Which Data Elements 3-9 Pertain. *(Multiple entry)*

1 ☐ Student 4 ☐ ATP 7 ☐ Single engine 10 ☐ Rotorcraft 13 ☐ Type rating
2 ☐ Private 5 ☐ Instructor 8 ☐ Multiengine 11 ☐ Glider A Other
3 ☐ Commercial 6 ☐ Instrument 9 ☐ Seaplane 12 ☐ Lighter Than Air (LTA)

3 Total Flight Hours When Certificate Rating Obtained _____ A Other

4 Source of Flight Training
1 ☐ 14 CFR 61 3 ☐ Military
2 ☐ 14 CFR 141 A Other

5 Recommending Flight Instructor Certificate # _____ A Other

6 Recommending Flight Instructor Status
1 ☐ Part-time
2 ☐ Full-time A Other

7 Flight Examiner *(Multiple entry)*
1 ☐ FAA employee 3 ☐ Company employee
2 ☐ FAA designee A Other

8 Flight Examiner # _____ A Other

9 Flight School Certificate # _____ A Other

Recency of Experience *(Complete only items related to accident.)*

	A Wpeks Since Last	B Other	C FLT Hours Since Last	D Other	E Done on FLT Check 1 Yes	2 No	F Other	G Done on BFR 1 Yes	2 No	H Other
10 Tailwheel Landing										
11 Crosswind Takeoff/Landing										
12 Short field Takeoff/Landing										
13 Go-Around										
14 Actual/Simulated Instrument										
15 Instrument Approach-Precision										
16 Instrument Approach-Nonprecision										
17 Unusual Attitude Practice										
18 Stall Practice										
19 Spin										
20 Sim/Act Engine Out in Multiengine										
21 Simulated Forced Landing										
22 180 Degree Accuracy Landing										
23 Autorotation										
24 Mountain flying										

25 Prior Experience in Geographical Area Last Year
1 ☐ Yes
2 ☐ No
A Other

26 Prior Experience at Airport/Airstrip Last Year
1 ☐ Yes
2 ☐ No
A Other

National Transportation Safety Board

FACTUAL REPORT AVIATION

NTSB Accident/Incident Number

Supplement F—Pilot Second Pilot Training and Proficiency (continued)

Second Pilot Information 1 ☐ *If pertinent certificate or rating obtained more than 2 years previous to accident, mark "X" here and proceed to block 39.*

31 Certificate and/or Rating For Which Data Elements 32-36 Pertain. *(Multiple entry)*

1 ☐ Student 4 ☐ ATP 7 ☐ Single engine 10 ☐ Rotorcraft 13 ☐ Type rating
2 ☐ Private 5 ☐ Instructor 8 ☐ Multiengine 11 ☐ Glider A Other
3 ☐ Commercial 6 ☐ Instrument 9 ☐ Seaplane 12 ☐ Lighter Than Air (LTA)

32 Total Flight Hours When Certificate Rating Obtained
A Other

33 Source of Flight Training
1 ☐ 14 CFR 61 3 ☐ Military
2 ☐ 14 CFR 141 A Other

34 Recommending Flight Instructor Certificate #
A Other

35 Recommending Flight Instructor Status
1 ☐ Part-time
2 ☐ Full-time A Other

36 Flight Examiner *(Multiple entry)*
1 ☐ FAA employee 3 ☐ Company employee
2 ☐ FAA designee A Other

37 Flight Examiner #
A Other

38 Flight School Certificate #
A Other

Recency of Experience *(Complete only items related to accident.)*

	A Weeks Since Last	B Other	C FLT Hours Since Last	D Other	E Done on FLT Check 1 Yes	2 No	F Other	G Done on BFR 1 Yes	2 No	H Other
39 Tailwheel Landing										
40 Crosswind Takeoff/Landing										
41 Short field Takeoff/Landing										
42 Go-Around										
43 Actual/Simulated Instrument										
44 Instrument Approach-Precision										
45 Instrument Approach-Nonprecision										
46 Unusual Attitude Practice										
47 Stall Practice										
48 Spin										
49 Sim/Act Engine Out in Multiengine										
50 Simulated Forced Landing										
51 180 Degree Accuracy Landing										
52 Autorotation										
53 Mountain flying										

54 Prior Experience in Geographical Area Last Year
1 ☐ Yes
2 ☐ No
A Other

55 Prior Experience at Airport/Airstrip Last Year
1 ☐ Yes
2 ☐ No
A Other

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NTSB Accident/Incident Number

Supplement G—Rotorcraft

1 Main Rotor Blade Type

1 ☐ Wood
2 ☐ Metal
3 ☐ Composite
A Other

2 Tail Rotor Blade Type

1 ☐ Wood
2 ☐ Metal
3 ☐ Composite
A Other

3 Auxiliary Fuel Tanks

1 ☐ None
2 ☐ Internal
3 ☐ External
A Other

4 IFR Certification

1 ☐ Single pilot
2 ☐ Dual Pilot IFR
3 ☐ None
A Other

5 Stability Augmentation System

1 ☐ Not installed
2 ☐ On
3 ☐ Off
4 ☐ On/off unknown
A Other

6 Engine Out Warning

1 ☐ Not installed
2 ☐ On
3 ☐ Off
4 ☐ On/off unknown
A Other

7 Low Rotor Speed Warning

1 ☐ Not installed
2 ☐ On
3 ☐ Off
4 ☐ On/off unknown
A Other

8 External Load Operations *(Multiple entry)*

1 ☐ Yes
2 ☐ No *(Go to block 16)*
3 ☐ Holds FAR 133 certificate
A Other

9 Type External Load Operation

1 ☐ Construction
2 ☐ Aerial Application
3 ☐ Logging
4 ☐ Medevac
5 ☐ Aerial survey
A Specify _____
B Other

10 Long Line

1 ☐ Yes
2 ☐ No *(Go to block 13)*
A Other

11 Length of Long Line

_____ Feet
A Other

12 Load Cell/Computer Utilized

1 ☐ Yes
2 ☐ No
A Other

13 Weight of External Load

1 ☐ Estimated
2 ☐ Verified
A _____ Lbs.
B Other

14 Load Jettisoned *(Multiple entry)*

1 ☐ External load
2 ☐ Long line
A Other

15 Landing Area *(Multiple entry)*

1 ☐ Level
2 ☐ Pinnacle
3 ☐ Confined area
A Slope _____ deg.
B Other

16 Obstructions

1 ☐ Trees
2 ☐ Wires/poles
3 ☐ Buildings/construction
4 ☐ Equipment/vehicles
5 ☐ Terrain
A Specify _____
B Other

17 Component Separation in Flight *(Multiple entry)*

1 ☐ None
2 ☐ General disintegration
3 ☐ Tailboom/cone
4 ☐ Stabilizer
5 ☐ Main rotor blade(s)
6 ☐ Main rotor hub assembly
7 ☐ Tail rotor blade(s)
8 ☐ Tail rotor hub assembly
9 ☐ Main transmission
10 ☐ Intermediate gear box
11 ☐ Tail rotor gear box
12 ☐ Vertical fin/pylon
13 ☐ Skids/Float(s)
14 ☐ Door(s)
A Other

18 Component Separation Postimpact *(Multiple entry)*

1 ☐ None
2 ☐ General disintegration
3 ☐ Tailboom/cone
4 ☐ Stabilizer
5 ☐ Main rotor blade(s)
6 ☐ Main rotor hub assembly
7 ☐ Tail rotor blade(s)
8 ☐ Tail rotor hub assembly
9 ☐ Main transmission
10 ☐ Intermediate gear box
11 ☐ Tail rotor gear box
12 ☐ Vertical fin/pylon
13 ☐ Skids/Float(s)
14 ☐ Door(s)
A Other

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Supplement H Aerial Application

1 Total Time *(Aerial Application)*

_____ Hours

A Other

2 Last 30 Days *(Aerial Application)*

_____ Hours

A Other

3 Last 24 Hours *(Aerial Application)*

_____ Hours

A Other

4 Total Night Time *(Aerial Application)*
(If N/A, go to block 7)

_____ Hours

A Other

5 Total Night, Last 30 Days *(Aerial Application)*

_____ Hours

A Other

6 Total Night, Last 24 Hours *(Aerial Application)*

_____ Hours

A Other

7 Type of Chemical Used

1 ☐ None
2 ☐ Dry chemical-toxic
3 ☐ Dry chemical-non-toxic
4 ☐ Liquid chemical-toxic
5 ☐ Liquid chemical-non-toxic
A Other

8 Name of Chemical

_____

A Other

9 Toxic Effect

1 ☐ Pilot not affected
2 ☐ Pilot affected in flight
3 ☐ Pilot affected prior to flight
4 ☐ Pilot affected postcrash
A Other

10 Duration of Exposure *(Last 24 hours)*

A _____ Hours
B _____ Minutes
C Other

11 Antidotes

1 ☐ Not available
2 ☐ Available-not used
3 ☐ Available-used
A Other

12 Respirator

1 ☐ Not available
2 ☐ Available-not used
3 ☐ Available-used
A Other

13 Gloves

1 ☐ Not used
2 ☐ Used
A Other

14 Goggles

1 ☐ Not used
2 ☐ Used
A Other

15 Helmet

1 ☐ Not used
2 ☐ Used
A Other

16 Crash Pad

1 ☐ Not installed
2 ☐ Installed
A Other

17 Crash Bar

1 ☐ Not installed
2 ☐ Installed
A Other

18 Tank/Hopper *(Multiple entry)*

1 ☐ Forward of pilot
2 ☐ Aft of pilot
3 ☐ Wings
4 ☐ Belly
5 ☐ Sides
6 ☐ Sling loaded
A Other

19 Obstructions *(Multiple entry)*

1 ☐ None
2 ☐ Trees
3 ☐ Wires/poles
4 ☐ Fences
5 ☐ Buildings
6 ☐ Towers
A Other

20 Terrain Being Treated *(Multiple entry)*

1 ☐ Level
2 ☐ Rolling
3 ☐ Hilly
4 ☐ Mountainous
5 ☐ Swampy
6 ☐ Dense-trees
A Other

21 Swath Run—Relative Wind

1 ☐ Crosswind
2 ☐ Upwind
3 ☐ Downwind
4 ☐ Wind calm
A Other

22 Procedure Turnaround

1 ☐ Not in procedure turnaround
2 ☐ Entry to procedure turn
3 ☐ First 1/3 of turn
4 ☐ Second 1/3 of turn
5 ☐ Third 1/3 of turn
A Other

23 Pilot Survey of Area *(Multiple entry)*

1 ☐ None
2 ☐ In-flight
3 ☐ On ground
A Other

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NTSB Accident/Incident Number

Supplement I—Crash Kinematics

1 Accident Site Geographic Coordinates—Latitude *(Multiple entry)*

1 ☐ North
2 ☐ South
A _____ deg. _____ minutes
B Other

2 Accident Site Geographic Coordinates—Longitude *(Multiple entry)*

1 ☐ East
2 ☐ West
A _____ deg. _____ minutes
B Other

3 Impact Sequence—*(Number in sequence. Multiple entry.)*

1 ☐ None
2 ☐ Rock face
3 ☐ Rigid structure
4 ☐ Rocks to 1' diam.
5 ☐ Rocks 1'-2' diam.
6 ☐ Rocks > 2' diam.
7 ☐ Ground
8 ☐ Dirt bank
9 ☐ Scrub tree
10 ☐ Trees/limbs to 6" diam.
11 ☐ Trees/limbs 6"-9" diam.
12 ☐ Trees/limbs 9"-12" diam.
13 ☐ Trees/limbs 12" diam. and up
14 ☐ Frangible approach aid
15 ☐ Non-frangible approach aid
16 ☐ Submerged obstacle
17 ☐ Vehicle
18 ☐ Aircraft
19 ☐ Runway light
20 ☐ Water
21 ☐ Wire
22 ☐ Pole
23 ☐ Snow bank
A Other

4 Terrain at Principal Impact Point *(Multiple entry)*

1 ☐ None
2 ☐ Wet cultivated soil
3 ☐ Dry cultivated soil
4 ☐ Dry packed clay
5 ☐ Boggy swampy
6 ☐ Packed snow
7 ☐ Loose snow
8 ☐ Concrete
9 ☐ Asphalt
10 ☐ Loose rock
11 ☐ Dry sod
12 ☐ Wet sod
13 ☐ Water
14 ☐ Tundra
15 ☐ Dirt
16 ☐ Rock
17 ☐ Ice
18 ☐ Mud
19 ☐ Sand
A Other

Principal Impact Kinematics

5 Airspeed At Impact *(Enter direct or mark estimated range)*

1 ☐ 0-15
2 ☐ 15-30
3 ☐ 30-45
4 ☐ 45-60
5 ☐ 60-75
6 ☐ 75-90
7 ☐ 90-120
8 ☐ 120-150
9 ☐ 150-180
10 ☐ 180-210
11 ☐ 210 plus knots
A _____ Knots
B Other

6 Flight Path Angle *(Enter direct or mark estimated range)*

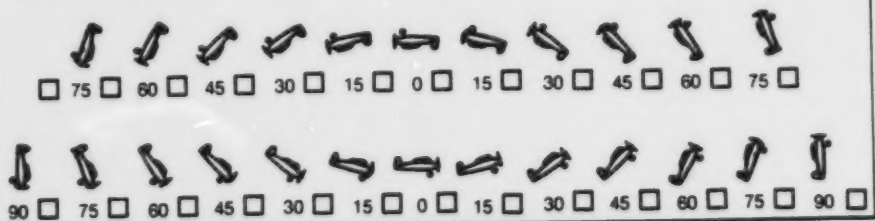
1 ☐ Up
2 ☐ Down
3 ☐ 0-5
4 ☐ 5-10
5 ☐ 10-15
6 ☐ 15-20
7 ☐ 20-25
8 ☐ 25-30
9 ☐ 30-45
10 ☐ 45-60
11 ☐ 60-90
A _____ Degrees
B Other

7 Pitch Attitude At Impact *(Enter direct or mark estimated range.)*

Pitch Attitude

1 ☐ Down
2 ☐ Up
A _____Deg.

Nose Down Angle With Horizon — Nose Up Angle With Horizon



☐ 75 ☐ 60 ☐ 45 ☐ 30 ☐ 15 ☐ 0 ☐ 15 ☐ 30 ☐ 45 ☐ 60 ☐ 75 ☐

90 ☐ 75 ☐ 60 ☐ 45 ☐ 30 ☐ 15 ☐ 0 ☐ 15 ☐ 30 ☐ 45 ☐ 60 ☐ 75 ☐ 90 ☐

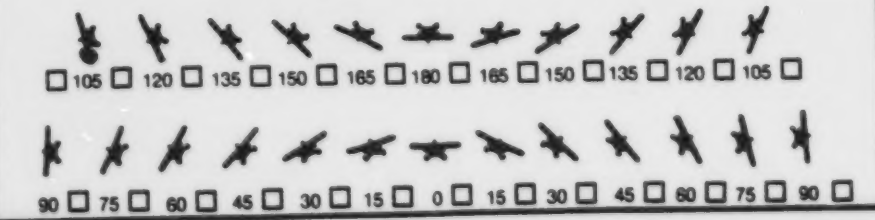
B or Other

8 Roll Attitude At Impact *(Enter direct or mark estimated range.)*

Roll

1 ☐ Left
2 ☐ Right
A _____Deg.

Aircraft Rolled Left — Aircraft Rolled Right



☐ 105 ☐ 120 ☐ 135 ☐ 150 ☐ 165 ☐ 180 ☐ 165 ☐ 150 ☐ 135 ☐ 120 ☐ 105 ☐

90 ☐ 75 ☐ 60 ☐ 45 ☐ 30 ☐ 15 ☐ 0 ☐ 15 ☐ 30 ☐ 45 ☐ 60 ☐ 75 ☐ 90 ☐

B or Other

National Transportation Safety Board

FACTUAL REPORT AVIATION

NTSB Accident/Incident Number

Supplement 1—Crash Kinematics (continued)

9 Yaw Attitude at Impact *(Enter direct or mark estimated range.)*

1 ☐ Nose left
2 ☐ Nose right
A _____ Deg.

Aircraft Yawed Left — Aircraft Yawed Right

90 ☐ 75 ☐ 60 ☐ 45 ☐ 30 ☐ 15 ☐ 0 ☐ 15 ☐ 30 ☐ 45 ☐ 60 ☐ 75 ☐ 90 ☐

or

B Other

10 Terrain Angle
1 ☐ Level
A Up _____ deg.
B Down _____ deg.
C Other

11 Principal Impact Ground Scar Length
1 ☐ None
A _____ feet
B Other

12 Principal Impact Ground Scar Depth
1 ☐ None
A _____ inches
B Other

13 Fuselage Totally Destroyed
1 ☐ Yes *(Go to block 36)*
2 ☐ No
A Other

14 Cockpit Damage *(Multiple entry)*
1 ☐ Destroyed
2 ☐ Collapsed
3 ☐ Part collapsed
4 ☐ Distorted
5 ☐ Burnt
6 ☐ Intact
7 ☐ None
A Other

15 FWD Cabin Damage *(Multiple entry)*
1 ☐ Destroyed
2 ☐ Collapsed
3 ☐ Part collapsed
4 ☐ Distorted
5 ☐ Burnt
6 ☐ Intact
7 ☐ None
A Other

16 AFT Cabin Damage *(Multiple entry)*
1 ☐ Destroyed
2 ☐ Collapsed
3 ☐ Part collapsed
4 ☐ Distorted
5 ☐ Burnt
6 ☐ Intact
7 ☐ None
A Other

17 Fuselage Split
1 ☐ No *(Go to block 19)*
2 ☐ Longitudinal
3 ☐ Circumferential
A Other

18 Fuselage Split Behind Seat #
_____
A Other

19 Fuselage Collapse *(Estimated)*
1 ☐ None
A Horizontal _____ inches
B Vertical _____ inches
C Other

20 Fuselage Crush
1 ☐ None
A Horizontal _____ inches
B Vertical _____ inches
C Other

Approved Exit Data

Exit Location	A Type of Exit				C Operable			E Fire Damage			G Impact Damage		
	1 Door	2 Window	3 Hatch	B Other	1 Yes	2 No	D Other	1 Yes	2 No	F Other	1 Yes	2 No	H Other
21 Cockpit-Left													
22 Cockpit Right													
23 1L													
24 1R													
25 2L													
26 2R													
27 3L													
28 3R													
29 4L													
30 4R													
31 5L													
32 5R													
33 6L													
34 6R													

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Supplement I - Crash Kinematics (continued)

Crash Site Plan/Elevation

36 **Sketch of Crash Site**—*Show distribution of major components, fire area, obstacles struck, occupants, and magnetic north. Sketch is "NOT TO SCALE".*

Plan View

Elevation View

National Transportation Safety Board

FACTUAL REPORT AVIATION

NTSB Accident/Incident Number

Supplement J—Water Contact Ditching

1 Intentional
1 ☐ Yes
2 ☐ No
A Other

2 Type of Water
1 ☐ Fresh
2 ☐ Salt
3 ☐ Open sea
4 ☐ Lake/river
A Other

3 Water Condition *(Multiple entry)*
1 ☐ Calm
2 ☐ Glassy
3 ☐ Rough
A Wave height _____ feet
B Swell height _____ feet
C Water temperature _____ °F
D Other

4 Water Contact Relative to Swell *(Estimated Range)*
1 ☐ 0-15°
2 ☐ 16-30°
3 ☐ 31-45°
4 ☐ 46-60°
5 ☐ 61-90°
A Other

5 Water Contact Relative to Wind
1 ☐ Into wind
2 ☐ Tail wind
3 ☐ Crosswind
4 ☐ Quartering headwind
5 ☐ Quartering tailwind
A Other

6 Occupied Area in Aircraft
1 ☐ Sunk immediately
2 ☐ Stayed afloat after evacuation
3 ☐ Stayed afloat for evacuation
A Other

7 Rescued By
1 ☐ Boat
2 ☐ Airplane
3 ☐ Helicopter
4 ☐ None
A Other

8 Occupant Time in Water
A _____ Hours
B _____ Minutes
C Other

9 Fire on Water
1 ☐ Yes
2 ☐ No
A Other

10 Fuel on Water
1 ☐ Yes
2 ☐ No
A

11 Floatation Devices on Aircraft *(Multiple entry)*
1 ☐ Sliderafl
2 ☐ Liferaft
3 ☐ Vest-inflatable
4 ☐ Vest-noninflatable
5 ☐ Cushion
A Specify _____
B Other

12 Floatation Equipment TSO'd *(Multiple entry)*
1 ☐ Sliderafl
2 ☐ Liferaft
3 ☐ Vest-inflatable
4 ☐ Vest-noninflatable
5 ☐ Cushion
A Specify _____
B Other

Signaling Devices
13 *(If none available, check block ☐ and go to block 22)*

	A Aboard A/C			C Available for Use			E Used			G Assisted in Locating			I Reasons Not Effective			
	1 Yes	2 No	B Other	1 Yes	2 No	D Other	1 Yes	2 No	F Other	1 Yes	2 No	H Other	1 Lost Missing	2 Failed in Use	3 Improper Use	J Other
14 Flare																
15 Smoke																
16 Dye																
17 Mirror																
18 Flashlight																
19 Aircraft Radio																
20 Portable Radio																
21 *(Specify)*																

This section to be completed for Rotorcraft accident/incidents ONLY.

22 Inflation of Floats *(Multiple entry)*
1 ☐ Prior to contact
2 ☐ After contact
3 ☐ Not equipped
A Other

23 Float Damage/Lost
1 ☐ Yes
2 ☐ No
A Other

24 Riding Qualities *(Multiple entry)*
1 ☐ Remained upright thru evac.
2 ☐ Asymmetrical bouyancy
3 ☐ Rolled during evac.
4 ☐ Rolled at contact
A Other

25 Antiexposure Suits *(Multiple entry)*
1 ☐ Available
2 ☐ Not available
3 ☐ Used
4 ☐ Not used
A Other

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Supplement K—Occupant, Survival and Injury Information

1 Seat No.
A _____
B If Seat Unknown Enter Persons Name _____
C Other

2 Position
1 ☐ Pilot in command
2 ☐ Second pilot
3 ☐ Other crewmember
4 ☐ Passenger
A Other

For non-survivable accident, go to block 36

3 Age
A _____ Yrs
B Under 24 mos., enter months _____
C Other

4 Height
_____ Inches
A Other

5 Weight
_____ Lbs
A Other

6 Injury Index
1 ☐ None
2 ☐ Minor
3 ☐ Serious
4 ☐ Fatal

7 Condition Prior to Accident *(Multiple entry)*
1 ☐ Smoker
2 ☐ Language difficulty
3 ☐ Pre-existing disease
4 ☐ Prothesis
A Other

8 Physically Handicapped *(Multiple entry)*
1 ☐ No
2 ☐ Blind
3 ☐ Mobility impaired
4 ☐ Deaf
A Other

9 Seat Belt Adjustment
1 ☐ Not fastened
2 ☐ Loose
3 ☐ Snug
4 ☐ Tight
5 ☐ Fastened-Tightness Unknown
6 ☐ Not seated
7 ☐ Seat not equipped
A Other

10 Shoulder Harness Adjustment
1 ☐ Not fastened
2 ☐ Loose
3 ☐ Snug
4 ☐ Tight
5 ☐ Fastened-Tightness Unknown
6 ☐ Seat not equipped
A Other

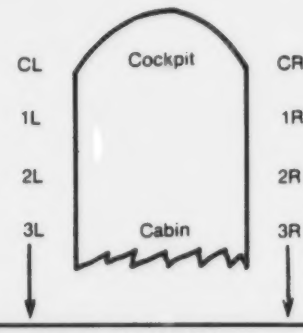
11 Knew Impact/Accident Coming
1 ☐ Yes
2 ☐ No
A Other

12 Braced for Impact
1 ☐ Yes
2 ☐ No
A Other

13 Direction of Movement at Impact *(Multiple entry)*
1 ☐ Forward
2 ☐ Rearward
3 ☐ Upward
4 ☐ Downward
5 ☐ Left
6 ☐ Right
A Other

14 Exit Used
1 ☐ Did not escape
2 ☐ Split in fuselage
A Exit number (use diagram) _____
B Other

Exit Diagram



Use following codes for overhead hatches

Cockpit 99

Cabin 88

Tailcone 77

15 Escape Hampered by *(Multiple entry)*
1 ☐ Not hampered
2 ☐ Smoke
3 ☐ Heat
4 ☐ Injuries
5 ☐ Trapped
6 ☐ Darkness
7 ☐ Debris
8 ☐ Disorientation
9 ☐ Difficulty Using Exit
A Specify _____
B Other

16 Briefed on Emergency Procedures *(Multiple entry)*
1 ☐ No
2 ☐ Before takeoff
3 ☐ Before impact/accident
A Other

17 Evacuation Aided by *(Multiple entry)*
1 ☐ Passenger
2 ☐ Crew
3 ☐ Bystander
4 ☐ CFR personnel
5 ☐ Unaided
A Other

18 Injured During Evacuation
1 ☐ Yes
2 ☐ No
A Other

Complete this section if oxygen was used.

21 Type of Equipment
1 ☐ Supplemental
2 ☐ Portable
A Other

22 Difficulty In Use
1 ☐ Yes
2 ☐ No
A Other

23 Type of Oxygen System
1 ☐ Solid state
2 ☐ Gaseous
A Specify _____
B Other

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Supplement K—Occupant, Survival and Injury Information (continued)

Complete this section for accidents involving fire.

24 ☐ No fire involved *(Go to block 29)*

25 Fire First Sighted *(Location)*
1 ☐ Inside aircraft
2 ☐ Outside aircraft
3 ☐ Both
A Other

26 Smoke Mask/Goggles Used *(Multiple entry)*
1 ☐ No
2 ☐ Yes
3 ☐ Both
4 ☐ Difficulty in use
A Other

27 Material of Clothes Worn *(Multiple entry)*
1 ☐ Synthetic
2 ☐ Nonsynthetic
3 ☐ Fire resistant
4 ☐ Mix-synthetic and nonsynthetic
A Other

28 Exposure to Heat/Fire *(Multiple entry)*
1 ☐ Head/face
2 ☐ Arm(s)
3 ☐ Hand(s)
4 ☐ Leg(s)
5 ☐ Torso
6 ☐ Feet
A Other

Complete this section for accidents involving ditching/water impact.

29 ☐ No water impact *(Go to block 36)*

Flotation Devices	A Available			C Used			E Familiar With Use			G Problems In Use			I Malfunctioned With Use			K Equipment Damaged		
	1 Yes	2 No	B Other	1 Yes	2 No	D Other	1 Yes	2 No	F Other	1 Yes	2 No	H Other	1 Yes	2 No	J Other	1 Yes	2 No	L Other
30 Liferaft																		
31 Vest-Inflatable																		
32 Vest-Non-Inflatable																		
33 Cushion																		

34 Time in Water
A _____ Hrs.
B _____ Mins.
C Other

35 Rescued by
1 ☐ Boat
2 ☐ Airplane
3 ☐ Helicopter
4 ☐ None
A Other

Occupant Injuries—*Complete applicable parts for survivors and nonsurvivors.*

Items 36 thru 39 apply ONLY to flight crewmembers.

36 Medication Prescribed
1 ☐ No
A Yes *(Specify:* _____*)*
B Other

37 Medication Being Taken
1 ☐ No
A Yes *(Specify:* _____*)*
B Other

38 Medication/Drugs Found
1 ☐ No
A Yes *(Specify:* _____*)*
B Other

39 Pre-existing Disease Found at Autopsy
1 ☐ No autopsy performed
2 ☐ None reported
A Yes *Specify:* _____
B Other

Results of Toxicological Analyses—*Complete as applicable for survivors and nonsurvivors.*

40 Toxicology *(Multiple entry)*
1 ☐ Not ordered
2 ☐ Not ordered—performed
3 ☐ Ordered—performed
4 ☐ Ordered—not performed
5 ☐ Embalmed
6 ☐ Specimen not available/unsuitable for analysis
A Other

National Transportation Safety Board

FACTUAL REPORT AVIATION

NTSB Accident/Incident Number

Supplement K—Occupant, Survival and Injury Information (continued)

Results of Toxicologial Analyses—*(Complete as applicable for survivors and nonsurvivors.) (continued)*

Substances	A Test Results: 1 Positive	2 Negative	B Other	C Level of Substances Found
41 Ethanol (Alcohol)				Mg %
42 CO (Carbon Monoxide)				% Saturation
43 hb (Hemoglobin)				gm %
44 HCN (Hydrogen Cyanide)				Microgram/ml
45 Acidic and Neutral Drugs				
46 Basic Drugs				
47 Marijuana				
48 (Specify) _____				

List any additional toxicological substances discovered below.

A Substance Code	B Level of Substances Found	A Substance Code	B Level of Substances Found
49		56	
50		57	
51		58	
52		59	
53		60	
54		61 (Specify)	
55		62 (Specify)	

Toxicological Substances/Codes

Acetamenophen	001	Cocaine	018	Imipramine	035	Menthol	052
Acetaldehyde	002	Codeine	019	Isopropanol	036	Morphine	053
Acetone	003	Desipramine	020	Ketamine	037	Medazepam	054
Amoxapine	004	Diazepam	021	Lidocaine	038	Nicotine	055
Amitriptyline	005	Dihydrocodeinone	022	Loxapine	047	Nortriptyline	056
Amobarbital	006	Diphenhydramine	023	Meclocqualone	039	Oxazepam	057
Amphetamine	007	Diphenylhydantoin	024	Meperidine	040	Pentazocine	058
Benzoylecgonine	008	Doxepin	025	Mephentermine	041	Phenobarbital	059
Brompheniramine	009	Desalkylflurazepam	026	Meprobamate	042	Procaine	060
Butalbital	010	Demoxapam	027	Methanol	043	Propoxyphene	061
Butabarbital	011	Ethchlorvynol	028	Methadone	044	Secobarbital	062
Caffene	012	Flunitrazepam	029	Methamphetamine	045	Thioridazine	063
Cannabinoids	013	Flurazepam	030	Methaqualone	046	Temazepam	064
Chlorazepate	014	Fluphenazine	031	Methylenedioxyam	048	Nordiazepam	065
Chlordiazepoxide	015	Glutethimide	032	Phetamine	049	Pentobarbital	066
Chlorphentermine	016	Haloperidol	033	Methylphenidate	050	Phencyclidine	067
Clonazepam	017	Hexobarbital	034	Methyprylon	051	Phendimetrazine	068
						Prazepam	069

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Supplement K—Occupant, Survival and Injury Information (continued)

63 ☐ *For multiple extreme traumatic injuries, check box, and go to next applicable supplement.*

Occupant Injury Coding Chart *(Complete for survivors and non survivors as applicable.)*

	A Body Region	B Aspect	C Lesion	D System/Organ	E A.I.S. Severity	F 6 Injury Source	G 7 Source of Data
64							
65							
66							
67							
68							
69							
70							
71							
72							
73							

Body Region - A

01 Head (Skull, scalp, ears)
02 Face (Forehead, nose, eyes, mouth)
03 Neck (Cervical spine, C1-C7)
04 Shoulder (Clavicle, scapula, joint)
05 Upper limb (Whole arm)
06 Arm (Upper)
07 Elbow
08 Forearm
09 Wrist
10 Hand—fingers
11 Chest (Anterior and posterior ribs)
12 Abdomen (Diaphragm and below)
13 Back (Thoracsic spine T1-T12)
14 Back (Lumbar L1-L5)
15 Pelvis—hip
16 Lower limb (Whole leg)
17 Thigh (Femur)
18 Knee
19 Leg (Below knee)
20 Ankle
21 Foot—toes
22 Whole body
88 Injured, unknown region
99 Other

Aspect Of Injury - B

01 Right
02 Left
88 Injured aspect unknown
99 Other

Lesion - C

01 Laceration
02 Contusion
03 Abrasion
04 Fracture
05 Concussion
06 Avulsion
07 Rupture
08 Sprain
09 Dislocation
10 Crush
11 Amputation
12 Burn
13 Fracture and dislocation
14 Severence (Transection)
15 Strain
16 Detachment (Separation)
17 Perforation (Puncture)
88 Injured unknown lesion
99 Other

System/Organ - D

01 Skeleal
02 Vertebrae
03 Joints
04 Digestive
05 Liver
06 Nervous System
07 Brain
08 Spinal cord
09 Ears
10 Arteries veins
11 Heart
12 Spleen
13 Urogenital
14 Kidneys
15 Respiratory
16 Eye
17 Pulmonary/lungs
18 Airway
19 Muscles
20 Integumentary
21 Thyroid (Thyroid or other endocrine gland)
88 Injured, unknown system or organ
99 Other

Abbreviated Injury Scale - E

00 Not injured
01 Minor injury
02 Moderate injury
03 Serious injury (Not life-threatening)
04 Severe injury (Life-threatening survival probable)
05 Critical injury (Survival uncertain)
06 Maximum (untreatable)
07 Injured (Unknown severity)
88 Unknown if injured

Source of Data - G

Official

01 Autopsy records with or without hospital/medical records
02 Hospital/medical records
03 Emergency room records
04 Private or treating physicians

Unofficial

05 Lay coroner
06 E.M.S. personnel
07 Interviewee
08 Police
09 Other source

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Supplement K—Occupant, Survival and Injury Information (continued)

Injury Source List - F

01 Windshield
02 Windshield frame
03 Window
04 Window frame
05 Instrument panel
06 Side console
07 Center console
08 Control stick/cyclic stick
09 Collective
10 Control yoke/column
11 Throttle quadrant/levers
12 Rudder pedals
13 Ceiling
14 Sidewall
15 Floor
16 Fuselage framing/structure
17 Table
18 Seat
19 Seatback tray
20 Restraints—seatbelt/tiedown
21 Restraints—shoulder harness
22 Unsecured item(s) in cockpit
23 Unsecured item(s) in cabin
24 Other occupants
25 Ground/runway
26 Unsecured seat(s)
27 Outside object(s) entering aircraft
28 Galley item(s)
29 Food/beverage item(s)
30 Other interior objects
31 Other exterior objects
32 Evacuation slide/slide raft
33 Escape rope/tape
34 Escape inertia device
35 Ejected from aircraft
36 Propeller/rotor blades
37 Exterior aircraft surface
38 Engine
39 Wheel/tires
40 Ground vehicle
41 Toxic/noxious/irritant fumes
42 Fire/radiant heat
43 Flying glass
44 Door/hatches
45 Acceleration forces
46 Exposure
47 Glare Shield
48 Eyeglasses
88 Unknown
99 Other

74 Death Due To Fire/Smoke

1 ☐ Yes
2 ☐ No
A Other

75 Death Due To Drowning

1 ☐ Yes
2 ☐ No
A Other

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Supplement L—Seat, Restraint System and Fuselage Deformation

Seat Information

1 Seat Number
_____
A Other

2 Seat Manufacturing Standard
1 ☐ Type certificate *(Airframe manufacturer)*
2 ☐ Non-TSO
A TSO *(Specify)* _____
B Other

3 Seat Orientation
1 ☐ Forward facing
2 ☐ Rearward facing
3 ☐ Side facing
A Other

4 Seat Unit
1 ☐ Fixed
2 ☐ Adjustable
3 ☐ Swivel
A Other

5 Seat Type *(Multiple entry)*
1 ☐ Cockpit crew
2 ☐ Flight attendant single jumpseat
3 ☐ Flight attendant double jumpseat
4 ☐ Folding stowable
5 ☐ Single passenger seat
6 ☐ 2 passenger seat unit
7 ☐ 3 passenger seat unit
8 ☐ Sofa/Bench
A Other

6 Seat Location at Time of Examination
1 ☐ Inside aircraft-attached
2 ☐ Inside aircraft-separated
3 ☐ Outside aircraft
A Other

7 Total Seat Destruction *(Multiple entry)*
1 ☐ Impact *(Go to block 30)*
2 ☐ Fire *(Go to block 30)*
A Other

8 Seat Anchored
1 ☐ Bulkhead/wall
2 ☐ Floor
A Other

9 Seat Primary Structure
1 ☐ Tube
2 ☐ Sheet metal
3 ☐ Composite
4 ☐ Wood
5 ☐ Metal Castings
A Other

10 Energy Absorbing Features
1 ☐ Yes
2 ☐ No
A Other

11 Evidence of Fire/Heat Damage *(Multiple entry)*
1 ☐ None
2 ☐ Cushions/covers
3 ☐ Structure
4 ☐ Restraints
A Other

Seat Installation/Damage/Displacement

12 Seat Impact Damage
1 ☐ None *(Omit 15-28 type impact damage)*

13 Seat Displacement
1 ☐ None *(Omit 15-28 direction of seat displacement)*

Seat Component *(Complete only pertinent items)*	A Installed 1 No	2 Yes	3 Improper Installation	B Other	C Type Impact Damage *(Multiple entry)* 1 None	2 Bent	3 Distorted/Buckled	4 Collapsed	5 Partially Separated	6 Separated	D Other	E Direction of Seat Displacement *(Multiple entry)* 1 None	2 Forward	3 Rearward	4 Left	5 Right	6 Up	7 Down	F Other
15 Pedestal																			
16 Enclosure																			
17 Back Frame																			
18 Seat Pan																			
19 Pan Frame																			
20 Legs																			
21 Leg Attach Fittings																			
22 Seat Attach Fittings																			
23 Structural Attach Fittings, Floor																			
24 Structural Attach Fittings, Wall																			
25 Seat Track																			
26 Arm Rest																			
27 Seat Back Tray																			
28 Head Restraint																			

Restraint System Information—

30 ☐ **Totally Destroyed** *(Go to block 46)*

31 Restraint System Manufacturer
_____
A Other

32 Restraint System TSO
1 ☐ Yes
2 ☐ No
A Other

33 Restraint System Design
1 ☐ 2-point
2 ☐ 3-point
3 ☐ 4-point
4 ☐ 5-point
A Other

34 Type Release/Buckle
1 ☐ Metal to metal
2 ☐ Fabric pull thru
A Specify _____
B Other

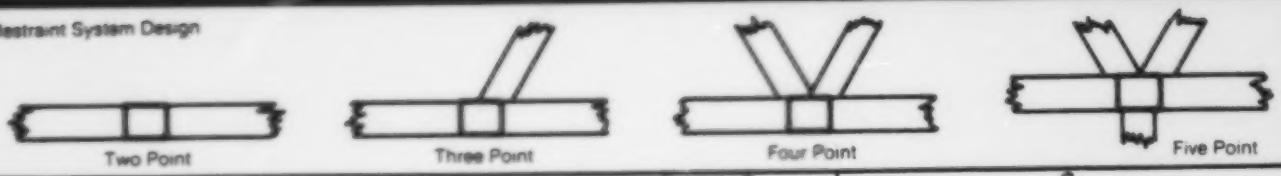
National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Supplement L—Seat, Restraint System and Fuselage Deformation (continued)

Restraint System Design



Component	A Installed			C Fire Damage			E Evidence of Use			G Location of Anchor Points					
	1 Yes	2 No	B Other	1 Yes	2 No	D Other	1 Yes	2 No	F Other	1 Seat	2 Wall	3 Floor	4 Ceiling	5 Bulkhead	H Other
35 Lapbelt															
36 Shoulder Harness															
37 Inertia Reel															
38 Tiedown Strap															

Component	A	B Webbing/Stitching			C Restraint Attach Fittings					D Seat/Structure Attach Fittings				
	1 No Damage	1 Destroyed	2 Partially Separated	3 Separated	1 No Damage	2 Destroyed	3 Bent	4 Partially Separated	5 Separated	1 No Damage	2 Destroyed	3 Bent	4 Partially Separated	5 Separated
39 Lapbelt														
40 Shoulder Harness														

41 Other Damage—Release Buckle
1 ☐ Yes
2 ☐ No A Other

42 Other Damage—Tie Down Strap
1 ☐ Yes
2 ☐ No A Other

43 Other Damage—Inertia Reel
1 ☐ Yes
2 ☐ No A Other

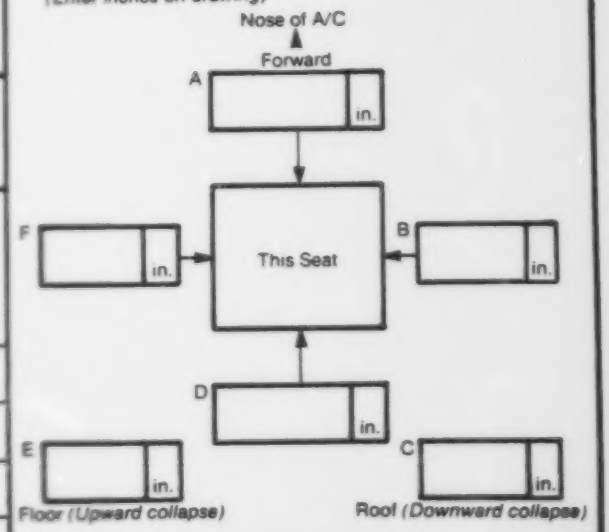
Fuselage Deformation Around This Seat

46 Fuselage Collapse Around This Seat
1 ☐ None
2 ☐ Collapse
3 ☐ Disintegrated/Incinerated A Other

47 Interior Surface Damage To This Seat
1 ☐ Yes
2 ☐ No
A Other

Cabin/Interior Deformation Around This Seat (Select codes from list below)	A Direction of Deformation						
	1 Forward	2 Rearward	3 Left	4 Right	5 Up	6 Down	B Other
50 Code _____							
51 Code _____							
52 Code _____							
53 Code _____							

48 Fuselage Collapse Measurements Around This Seat
(Enter inches on drawing)



Note: Arrow (——→) shows direction of displacement

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Supplement L—Seat, Restraint System and Fuselage Deformation (continued)

(Codes to be used in 50-53 above)

01 Windshield
02 Windshield frame
03 Window
04 Window frame
05 Instrument panel
06 Side console
07 Center console
08 Control stick/cyclic stick
09 Collective
10 Control yoke/column
11 Throttle quadrant/levers
12 Rudder pedals
13 Ceiling
14 Sidewall
15 Floor
16 Fuselage framing/structure
17 Table
18 Seat
19 Seatback tray
20 Restraints—seatbelt/tiedown
21 Restraints—shoulder harness
22 Unsecured item(s) in cockpit
23 Unsecured item(s) in cabin
24 Other occupants
25 Ground/runway
26 Unsecured seat(s)
27 Galley item(s)
28 Other interior objects
29 Door/hatches

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Supplement M—Search Rescue Firefighting Medical Treatment

Search and Rescue 1 ☐ **None Conducted** *(Go to block 16)*

2 Type of Search Conducted *(Multiple entry)*
1 ☐ Air
2 ☐ Ground
3 ☐ Sea
4 ☐ Informal
A Other

4 Search Agency Notified
A _____ *(Nos. for M. D. Y)*
B _____ Local time
C Other

5 Aircraft/Occupants Located
A _____ *(Nos. for M. D. Y)*
B _____ Local time
C Other

7 Civil Air Patrol Involved in Search
1 ☐ Yes
2 ☐ No
A Other

8 Military or Coast Guard Personnel Involved
1 ☐ Yes
2 ☐ No
A Other

9 Distress Call Transmitted *(Multiple entry)*
1 ☐ None transmitted
2 ☐ Prior to accident
3 ☐ After impact/accident
A Other

10 Distress Call Received *(Multiple entry)*
1 ☐ None received
2 ☐ Prior to accident
3 ☐ After impact/accident
A Other

11 Method of Locating Accident Site *(Multiple entry)*
1 ☐ ELT
2 ☐ HF radio
3 ☐ VHF radio
4 ☐ UHF radio
5 ☐ Visual sighting of wreckage
6 ☐ Visual sighting of occupants
7 ☐ Visual sighting of signal/smoke/fire
8 ☐ SAR satellite
9 ☐ ATC computer generated
A Other

12 Condition of Aircraft Occupants at Rescue *(Multiple entry)*
1 ☐ Located alive
2 ☐ Located deceased
3 ☐ Located alive-died later
4 ☐ Died awaiting rescue
5 ☐ Located alive-trapped
6 ☐ Able to assist with locating
7 ☐ Left scene-successfully located
8 ☐ Left scene-unsuccessful in finding aid
9 ☐ Left scene-unsuccessful in finding aid—died later
A Other

13 Weather Conditions—Indicate Most Severe Temperature/Wind Chill Condition During Search
A Temperature _____ °F
B Wind/chill factor _____ °F
C Other

Fire Fighting 16 ☐ **None Conducted** *(Go to block 31)*

17 Firefighting Unit Notified *(Nos. for M. D. Y)*
A _____
B _____ Local time
C Other

18 First Firefighting Unit Arrived
_____ Local time
A Other

19 Firefighting Units Responding *(Multiple entry)*
1 ☐ Airport
2 ☐ Municipal
3 ☐ Military
A Other

20 Firefighting Units Assisted Evacuation
1 ☐ Yes
2 ☐ No
A Other

21 Fire Extinguished
_____ Local time
A Other

Firefighting Agents	A Available			C Used		
	1 Yes	2 No	B Other	1 Yes	2 No	D Other
22 Protein Foam						
23 Dry Chemical						
24 Carbon Dioxide						
25 AFFF (Lite Water)						
26 Water						
28 *(Specify)* _____						

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Supplement M—Search Rescue Firefighting Medical Treatment (continued)

Search and Rescue, Firefighting, Medical Treatment

31 Medical Units Responding *(Doctor or paramedic) (Multiple entry)*

1 ☐ None provided
2 ☐ Airport
3 ☐ Municipal
4 ☐ Other paramedics
5 ☐ Military
A Other

35 Search and Rescue, Firefighting, Medical Treatment Units Hampered

1 ☐ Yes *(Complete items 36-51)*
2 ☐ No
A Other

Search and Rescue, Firefighting, Medical Treatment Units Hampered by	1 Search and Rescue	2 Firefighting	3 Medical Treatment
36 Weather/Visibility			
37 Terrain			
38 Darkness			
39 Unfamiliarity With Terrain			
40 Maps Inadequate/Inaccurate			
41 Obstacles			
42 Training of Personnel			
43 Other Vehicles			
44 Traffic			
45 Coordination Problem			
46 Inadequate Emergency Plan/Planning			
47 Command Problem			
48 Communication Problem			
49 Equipment Unable on Terrain			
50 Did Not Adhere to Emergency Plan			
51 *(Specify)* _____			

National Transportation Safety Board

FACTUAL REPORT AVIATION

NTSB Accident/Incident Number

Supplement N—Fire Explosion

1 Fire Started

1 ☐ In-flight
2 ☐ During ground operation
3 ☐ During impact sequence
4 ☐ After aircraft came to rest
5 ☐ Greater than 1 minute after aircraft came to rest
A Other

Location of Initial Fire or Explosion (Specify)	A 1 Fire	B 1 Explosion	C In-Flight 1 Yes	C In-Flight 2 No	C In-Flight D Other	E On Ground 1 Yes	E On Ground 2 No	E On Ground F Other	G After Impact 1 Yes	G After Impact 2 No	G After Impact H Other
2											
3											
4											

5 Fire/Explosion Ignition Source(s) *(Multiple entry)*

1 ☐ Engine
2 ☐ APU
3 ☐ Hot surface
4 ☐ Explosive
5 ☐ Aircraft system
6 ☐ Cargo
7 ☐ Short circuit
8 ☐ Static electricity
9 ☐ Lightning
10 ☐ Sparks *(Friction, skidding, etc.)*
11 ☐ Ground vehicle
12 ☐ Ground structure
13 ☐ Aircraft occupant
A Other

6 Fluid Spilled

1 ☐ Yes
2 ☐ No *(Go to block 8)*
A Other

7 Type of Fluid Spilled *(Multiple entry)*

1 ☐ Fuel
2 ☐ Oil
3 ☐ Hydraulic
A Other

8 Other Fuels Present *(Multiple entry)*

1 ☐ Natural gas
2 ☐ Heating oil
3 ☐ Gasoline
4 ☐ Kerosene
5 ☐ Explosives
6 ☐ None
A Other

9 Fire Propagation Direction *(Multiple entry)*

1 ☐ Forward
2 ☐ Rearward
3 ☐ Upward
4 ☐ Downward
5 ☐ Left to right
6 ☐ Right to left
A Other

10 Percent of Occupiable Space in Fire Area at Time of Evacuation

_____ Percent

A Other

11 Ground Structure Burned *(Multiple entry)*

1 ☐ Single family house
2 ☐ Multifamily house
3 ☐ Commercial building
4 ☐ Farm building
5 ☐ Trees
6 ☐ Vehicle
7 ☐ Other aircraft
8 ☐ None
A Other

12 Fire Sensing and Extinguishing Systems Installed/Available

1 ☐ Yes
2 ☐ No *(Omit blocks 13-34)*
3 ☐ Not pertinent to accident *(Omit blocks 13-34)*
A Other

Sensors Extinguishers	Sensors A Available 1 Yes	Sensors A Available 2 No	Sensors A Available B Other	Sensors C Type of Sensor 1 Heat	Sensors C Type of Sensor 2 Smoke	Sensors C Type of Sensor 3 Optic	Sensors C Type of Sensor D Other	Extinguishers E Available 1 Yes	Extinguishers E Available 2 No	Extinguishers E Available F Other	Extinguishers G Number 1 Number	Extinguishers G Number H Other	Extinguishers I Type of Extinguisher 1 Manual	Extinguishers I Type of Extinguisher 2 Automatic	Extinguishers I Type of Extinguisher J Other
13 Engine #1															
14 Engine #2															
15 Engine #3															
16 Engine #4															
17 APU															

National Transportation Safety Board

FACTUAL REPORT AVIATION

NTSB Accident/Incident Number

Supplement N—Fire Explosion (continued)

Sensors Extinguishers	Sensors							Extinguishers							
	A Available			C Type of Sensor				E Available			G Number		I Type of Extinguisher		
	1 Yes	2 No	B Other	1 Heat	2 Smoke	3 Optic	D Other	1 Yes	2 No	F Other	1 Number	H Other	1 Manual	2 Automatic	J Other
20 Galley															
21 Lavatory															
22 Heater															
23 Battery															
24 Electrical System															
25 *Specify* _____															
26 *Specify* _____															
27 *Specify* _____															

Sensor Operation	Engine #1 1	Engine #2 2	Engine #3 3	Engine #4 4	APU 5	Cabin 6	Cargo 7	Galley 8	Lavatory 9	Heater 10	Battery 11	Electrical Sys. 12	Other A
28 Activated													
29 Did Not Activate													

Extinguisher Operation	Engine #1 A	Engine #2 B	Engine #3 C	Engine #4 D	APU E	Cabin F	Cargo G	Galley H	Lavatory I	Heater J	Battery K	Electrical Sys. L	Other M
Number Activated _____ 30 Man													
31 Auto													
# Did Not Activate _____ 32 Man													
33 Auto													

34 Extinguisher Systems/Agents Used *(Multiple entry)*

1 ☐ Fixed equipment
2 ☐ Portable equipment
3 ☐ CO_2 (Carbon Dioxide)
4 ☐ CB (Chlorobroyethane)
5 ☐ Halon 1211
6 ☐ ME (Methylbromide)
7 ☐ Halon 1301
A Other

National Transportation Safety Board

FACTUAL REPORT AVIATION

NTSB Accident/Incident Number

Supplement O—In-Flight Collision

	Aircraft A	Aircraft B
1 Aircraft Registration Number		
2 Aircraft Heading	_____ ° mag A Other	_____ ° mag A Other
3 True Airspeed	_____ Kts A Other	_____ Kts A Other
4 Direction of Bank	1 ☐ None 3 ☐ Right 2 ☐ Left A Other	1 ☐ None 3 ☐ Right 2 ☐ Left A Other
5 Climb/Descent	1 ☐ Level 3 ☐ Descent 2 ☐ Climb A Other	1 ☐ Level 3 ☐ Descent 2 ☐ Climb A Other
6 Evasive Action *(Multiple entry)*	1 ☐ None 4 ☐ Climb A Other 2 ☐ Right turn 5 ☐ Descent 3 ☐ Left turn 6 ☐ Abrupt	1 ☐ None 4 ☐ Climb A Other 2 ☐ Right turn 5 ☐ Descent 3 ☐ Left turn 6 ☐ Abrupt
7 Rotating Beacon On	1 ☐ Yes 2 ☐ No A Other	1 ☐ Yes 2 ☐ No A Other
8 Strobe Lights On	1 ☐ Yes 2 ☐ No A Other	1 ☐ Yes 2 ☐ No A Other
Collision Avoidance (CA) — 9 Type CA System Installed	1 ☐ None B Other A Specify _____	1 ☐ None B Other A Specify _____
Collision Avoidance (CA) — 10 CA Operation	1 ☐ Operating A Other 2 ☐ Not operating	1 ☐ Operating A Other 2 ☐ Not operating
Collision Avoidance (CA) — 11 CA Identification	1 ☐ Target identified A Other 2 ☐ Target not identified	1 ☐ Target identified A Other 2 ☐ Target not identified
12 Traffic Advisory Issued *(Multiple entry)*	1 ☐ None 6 ☐ Approach Control *(Non radar)* 2 ☐ UNICOM 3 ☐ Control Tower 7 ☐ Approach Control *(Radar)* 4 ☐ ARTCC *(Non radar)* 5 ☐ ARTCC *(Radar)* 8 ☐ Flight service station A Other	1 ☐ None 6 ☐ Approach Control *(Non radar)* 2 ☐ UNICOM 3 ☐ Control Tower 7 ☐ Approach Control *(Radar)* 4 ☐ ARTCC *(Non radar)* 5 ☐ ARTCC *(Radar)* 8 ☐ Flight service station A Other
13 Radar Control Surveillance	1 ☐ Radar not available 4 ☐ No radar contact 2 ☐ Under radar contact A Other 3 ☐ During radar handoff	1 ☐ Radar not available 4 ☐ No radar contact 2 ☐ Under radar contact A Other 3 ☐ During radar handoff
14 Conflict Alert Issued	1 ☐ Yes 2 ☐ No A Other	1 ☐ Yes 2 ☐ No A Other
15 Conflict Alert Received	1 ☐ Yes 2 ☐ No A Other	1 ☐ Yes 2 ☐ No A Other
16 Landed Safely	1 ☐ Yes 2 ☐ No A Other	1 ☐ Yes 2 ☐ No A Other

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Supplement P—Air Traffic Control

1 Facility Identifier *(3 letter code)*

_____

2 Facility Level

1 ☐ I
2 ☐ II
3 ☐ III
4 ☐ IV
5 ☐ V
A Other

3 Type of Facility

1 ☐ ARTCC
2 ☐ Radar
3 ☐ CERAP
4 ☐ Nonradar
5 ☐ Tower
6 ☐ VFR
7 ☐ TRACON
8 ☐ RAPCON
9 ☐ IFR
10 ☐ Temporary
11 ☐ RATCF
12 ☐ FSS
13 ☐ IFSS
14 ☐ FCT
A Other

Terminal Facility *(If not applicable, go to 19)*

	A Installed		B Functioning		C Other
	1 Yes	2 No	1 Yes	2 No	
5 Airport Surveillance Radar (ASR)					
6 Precision Approach Radar (PAR)					
7 TPX-42					
8 ARTS II (Automated Radar Terminal System)					
9 ARTS II A					
10 ARTS III					
11 ARTS III A					
12 PIDP (Position Indicating Data Processor)					
13 BRITE					
14 ASDE (Airport Surface Detection Equipment)					
15 MSAW (Minimum Safe Altitude Warning)					
16 Conflict Alert					
17 LLWSAS (Low Level Wind Shear Alert System)					
18					

Enroute ARTCC Facilities *(If not applicable, go to 28)*

	A Installed		B Functioning		C Other
	1 Yes	2 No	1 Yes	2 No	
19 Long Range Radar					
20 SECRA (Secondary Radar)*(beacon only)*					
21 En route ARTS					
22 DARC (Direct Access Radar Channel)					
23 CWSU (Center Weather Service Unit)					
24 Weather Radar/NEXRAD					
25 E/MSAW (En route Minimum Safe Altitude Warning)					
26 E/Conflict Alert					
27 ATC Computer					

Air Traffic Controller(s) Information Controller No. 1

28 Facility Identifier *(3 letter code)*

_____

29 Facility Level

1 ☐ I
2 ☐ II
3 ☐ III
4 ☐ IV
5 ☐ V
A Other

30 Type of Facility

1 ☐ ARTCC
2 ☐ Radar
3 ☐ CERAP
4 ☐ Nonradar
5 ☐ Tower
6 ☐ VFR
7 ☐ TRACON
8 ☐ RAPCON
9 ☐ IFR
10 ☐ Temporary
11 ☐ RATCF
12 ☐ FSS
13 ☐ IFSS
14 ☐ FCT
A Other

National Transportation Safety Board

FACTUAL REPORT AVIATION

NTSB Accident/Incident Number

Supplement P—Air Traffic Control (continued)

31 Controller Status
1 ☐ ATCS (FPL)
2 ☐ ATCS (DEV)
3 ☐ SATCS
4 ☐ PPS
5 ☐ EPDS
6 ☐ DSS
7 ☐ Military
8 ☐ Staff
A Other

32 Date of Last Medical *(Nos. for M, D, Y)*
_____
A Other

Waivers

33 Visual
1 ☐ Yes
2 ☐ No

34 Hearing
1 ☐ Yes
2 ☐ No

35 None 1 ☐

36 Other

37 Weather Observer
1 ☐ Yes
2 ☐ No
A Other

38 Date of Birth *(Nos. for M, D, Y)*

39 EOD Facility *(Nos. for M, D, Y)*

40 EOD ATC *(Nos. for M, D, Y)*

41 Position Rated *(Nos. for M, D, Y)*

Position Occupied *(Multiple entry)*

42 Tower
1 ☐ Local
2 ☐ Ground
3 ☐ Flt data/clearance delivery
4 ☐ Nonradar approach control
5 ☐ Radar/BRITE
6 ☐ ASDE
7 ☐ Coordinator
8 ☐ Supervisor
A Other

43 Approach Control
1 ☐ Arrival
2 ☐ Departure
3 ☐ ASR
4 ☐ PAR
5 ☐ Data
6 ☐ Handoff
7 ☐ Coordinator
8 ☐ Supervisor
A Other

44 En Route
1 ☐ Radar
2 ☐ Nonradar
3 ☐ Handoff
4 ☐ Data
5 ☐ Flow controller
6 ☐ Coordinator
7 ☐ Supervisor
A Other

45 Flight Service
1 ☐ In-flight
2 ☐ EFAS
3 ☐ Direction finder
4 ☐ Weather briefer
5 ☐ Coordinator
6 ☐ Supervisor
A Other

46 Positions Combined
1 ☐ Yes
2 ☐ No

47 Time on Duty
A _____ Hrs
B _____ Minutes
C Other

48 Time on Position
A _____ Hrs
B _____ Minutes
C Other

49 Rest Period
A _____ Hrs
B _____ Minutes
C Other

50 Aeronautical Rating
1 ☐ Yes
2 ☐ No
A Other

Air Traffic Controller(s) Information Controller No. 2

51 Facility Identifier *(3 letter code)*
_____

52 Facility Level
1 ☐ I
2 ☐ II
3 ☐ III
4 ☐ IV
5 ☐ V
A Other

53 Type of Facility
1 ☐ ARTCC
2 ☐ Radar
3 ☐ CERAP
4 ☐ Nonradar
5 ☐ Tower
6 ☐ VFR
7 ☐ TRACON
8 ☐ RAPCON
9 ☐ IFR
10 ☐ Temporary
11 ☐ RATCF
12 ☐ FSS
13 ☐ IFSS
14 ☐ FCT
A Other

54 Controller Status
1 ☐ ATCS (FPL)
2 ☐ ATCS (DEV)
3 ☐ SATCS
4 ☐ PPS
5 ☐ EPDS
6 ☐ DSS
7 ☐ Military
8 ☐ Staff
A Other

55 Date of Last Medical *(Nos. for M, D, Y)*
_____
A Other

Waivers

56 Visual
1 ☐ Yes
2 ☐ No

57 Hearing
1 ☐ Yes
2 ☐ No

58 None 1 ☐

59 Other

60 Weather Observer
1 ☐ Yes
2 ☐ No
A Other

61 Date of Birth

62 EOD Facility *(Nos. for M, D, Y)*

63 EOD ATC *(Nos. for M, D, Y)*

64 Position Rated *(Nos. for M, D, Y)*

Position Occupied *(Multiple entry)*

65 Tower
1 ☐ Local
2 ☐ Ground
3 ☐ Flt data/clearance delivery
4 ☐ Nonradar approach control
5 ☐ Radar/BRITE
6 ☐ ASDE
7 ☐ Coordinator
8 ☐ Supervisor
A Other

66 Approach Control
1 ☐ Arrival
2 ☐ Departure
3 ☐ ASR
4 ☐ PAR
5 ☐ Data
6 ☐ Handoff
7 ☐ Coordinator
8 ☐ Supervisor
A Other

67 En Route
1 ☐ Radar
2 ☐ Nonradar
3 ☐ Handoff
4 ☐ Data
5 ☐ Flow controller
6 ☐ Coordinator
7 ☐ Supervisor
A Other

68 Flight Service
1 ☐ In-flight
2 ☐ EFAS
3 ☐ Direction finder
4 ☐ Weather briefer
5 ☐ Coordinator
6 ☐ Supervisor
A Other

National Transportation Safety Board

FACTUAL REPORT AVIATION

NTSB Accident/Incident Number

Supplement P—Air Traffic Control (continued)

69 Positions Combined
1 ☐ Yes
2 ☐ No

70 Time on Duty
A _____ Hrs
B _____ Minutes
C Other

71 Time on Position
A _____ Hrs
B _____ Minutes
C Other

72 Rest Period
A _____ Hrs
B _____ Minutes
C Other

73 Aeronautical Rating
1 ☐ Yes
2 ☐ No
A Other

Air Traffic Controller(s) Information Controller No. 3

78 Facility Identifier *(3 letter code)*
_____

79 Facility Level
1 ☐ I
2 ☐ II
3 ☐ III
4 ☐ IV
5 ☐ V
A Other

80 Type of Facility
1 ☐ ARTCC
2 ☐ Radar
3 ☐ CERAP
4 ☐ Nonradar
5 ☐ Tower
6 ☐ VFR
7 ☐ TRACON
8 ☐ RAPCON
9 ☐ IFR
10 ☐ Temporary
11 ☐ RATCF
12 ☐ FSS
13 ☐ IFSS
14 ☐ FCT
A Other

81 Controller Status
1 ☐ ATCS (FPL)
2 ☐ ATCS (DEV)
3 ☐ SATCS
4 ☐ PPS
5 ☐ EPDS
6 ☐ DSS
7 ☐ Military
8 ☐ Staff
A Other

82 Date of Last Medical *(Nos. for M. D. Y)*
_____
A Other

Waivers

83 Visual
1 ☐ Yes
2 ☐ No

84 Hearing
1 ☐ Yes
2 ☐ No

85 None 1 ☐

86 Other

87 Weather Observer
1 ☐ Yes
2 ☐ No
A Other

88 Date of Birth *(Nos. for M. D. Y)*

89 EOD Facility *(Nos. for M. D. Y)*

90 EOD ATC *(Nos. for M. D. Y)*

91 Position Rated *(Nos. for M. D. Y)*

Position Occupied *(Multiple entry)*

92 Tower
1 ☐ Local
2 ☐ Ground
3 ☐ Flt data/clearance delivery
4 ☐ Nonradar approach control
5 ☐ Radar/BRITE
6 ☐ ASDE
7 ☐ Coordinator
8 ☐ Supervisor
A Other

93 Approach Control
1 ☐ Arrival
2 ☐ Departure
3 ☐ ASR
4 ☐ PAR
5 ☐ Data
6 ☐ Handoff
7 ☐ Coordinator
8 ☐ Supervisor
A Other

94 En Route
1 ☐ Radar
2 ☐ Nonradar
3 ☐ Handoff
4 ☐ Data
5 ☐ Flow controller
6 ☐ Coordinator
7 ☐ Supervisor
A Other

95 Flight Service
1 ☐ In-flight
2 ☐ EFAS
3 ☐ Direction finder
4 ☐ Weather briefer
5 ☐ Coordinator
6 ☐ Supervisor
A Other

96 Positions Combined
1 ☐ Yes
2 ☐ No

97 Time on Duty
A _____ Hrs
B _____ Minutes
C Other

98 Time on Position
A _____ Hrs
B _____ Minutes
C Other

99 Rest Period
A _____ Hrs
B _____ Minutes
C Other

100 Aeronautical Rating
1 ☐ Yes
2 ☐ No
A Other

Air Traffic Controller(s) Information Controller No. 4

101 Facility Identifier *(3 letter code)*
_____

102 Facility Level
1 ☐ I
2 ☐ II
3 ☐ III
4 ☐ IV
5 ☐ V
A Other

103 Type of Facility
1 ☐ ARTCC
2 ☐ Radar
3 ☐ CERAP
4 ☐ Nonradar
5 ☐ Tower
6 ☐ VFR
7 ☐ TRACON
8 ☐ RAPCON
9 ☐ IFR
10 ☐ Temporary
11 ☐ RATCF
12 ☐ FSS
13 ☐ IFSS
14 ☐ FCT
A Other

104 Controller Status
1 ☐ ATCS (FPL)
2 ☐ ATCS (DEV)
3 ☐ SATCS
4 ☐ PPS
5 ☐ EPDS
6 ☐ DSS
7 ☐ Military
8 ☐ Staff
A Other

105 Date of Last Medical *(Nos. for M. D. Y)*
_____
A Other

Waivers

106 Visual
1 ☐ Yes
2 ☐ No

107 Hearing
1 ☐ Yes
2 ☐ No

108 None 1 ☐

109 Other

110 Weather Observer
1 ☐ Yes
2 ☐ No
A Other

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Supplement P—Air Traffic Control (continued)

111 Date of Birth *(Nos. for M. D. Y)*

112 EOD Facility *(Nos. for M. D. Y)*

113 EOD ATC *(Nos. for M. D. Y)*

114 Position Rated *(Nos. for M. D. Y)*

Position Occupied *(Multiple entry)*

115 Tower
- 1 ☐ Local
- 2 ☐ Ground
- 3 ☐ Flt data/clearance delivery
- 4 ☐ Nonradar approach control
- 5 ☐ Radar/BRITE
- 6 ☐ ASDE
- 7 ☐ Coordinator
- 8 ☐ Supervisor
- A Other

116 Approach Control
- 1 ☐ Arrival
- 2 ☐ Departure
- 3 ☐ ASR
- 4 ☐ PAR
- 5 ☐ Data
- 6 ☐ Handoff
- 7 ☐ Coordinator
- 8 ☐ Supervisor
- A Other

117 En Route
- 1 ☐ Radar
- 2 ☐ Nonradar
- 3 ☐ Handoff
- 4 ☐ Data
- 5 ☐ Flow controller
- 6 ☐ Coordinator
- 7 ☐ Supervisor
- A Other

118 Flight Service
- 1 ☐ In-flight
- 2 ☐ EFAS
- 3 ☐ Direction finder
- 4 ☐ Weather briefer
- 5 ☐ Coordinator
- 6 ☐ Supervisor
- A Other

119 Positions Combined
- 1 ☐ Yes
- 2 ☐ No

120 Time on Duty
- A _____ Hrs
- B _____ Minutes
- C Other

121 Time on Position
- A _____ Hrs
- B _____ Minutes
- C Other

122 Rest Period
- A _____ Hrs
- B _____ Minutes
- C Other

123 Aeronautical Rating
- 1 ☐ Yes
- 2 ☐ No
- A Other

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Supplement Q Airport Airstrip

1 Distance From Runway *(Multiple entry)*
1 ☐ On airport/airstrip or B Other
2 ☐ Approach end
3 ☐ Departure end
A Distance _____ NM

2 Bearing From Runway *(Multiple entry)*
1 ☐ On airport/airstrip or B Other
2 ☐ Approach end
3 ☐ Departure end
A Bearing _____ Mag.

3 Type of Airport/Airstrip *(Multiple entry)*
1 ☐ Land
2 ☐ Water
3 ☐ Heliport
4 ☐ Oil rig
5 ☐ Private use
6 ☐ Public use
A Other

4 Airport Category
1 ☐ Commercial service
2 ☐ Reliever
3 ☐ General aviation
A Other

5 Airport Certification (FAR 139)
1 ☐ Full certification
2 ☐ Limited certification
3 ☐ None *(Go to block 8)*
A Other

6 Emergency Plan Tested
1 ☐ Yes
2 ☐ No
A Other

7 Months Since Emergency Plan Tested
_____
A Other

8 Instrument Approach to Active Runway *(Multiple entry)*
1 ☐ None
2 ☐ Nonprecision approach
3 ☐ Precision approach
4 ☐ CAT I
5 ☐ CAT II
6 ☐ CAT IIIA
7 ☐ CAT IIIB
A Other

9 Runway/Landing Surface Treatment *(Multiple entry)*
1 ☐ Porous
2 ☐ Smooth texture
3 ☐ Rough texture
4 ☐ Partially grooved
5 ☐ Fully grooved
A Other

10 Runway Overrun *(Dep end)*
1 ☐ Yes
2 ☐ No
A Other

11 Length of Overrun
_____ Feet
A Other

12 Displaced Threshold
1 ☐ Yes
2 ☐ No
A Other

13 Length of Displaced Threshold
_____ Feet
A Other

14 Obstacles—Runway End to Airport/Airstrip Boundary *(Multiple entry)*
1 ☐ None
2 ☐ Approach lights
3 ☐ Approach/navaids
4 ☐ Building(s)
5 ☐ Wire(s)
6 ☐ Pole(s)
7 ☐ Tree(s)
8 ☐ Tower(s)
9 ☐ Dirt bank
10 ☐ Snow bank
11 ☐ Ditch
12 ☐ Water
13 ☐ Vertical drop
14 ☐ High terrain
A Other

15 Obstacles—Airport Boundary To 2 NM *(Multiple entry)*
1 ☐ None
2 ☐ Approach lights
3 ☐ Approach/navaids
4 ☐ Building(s)
5 ☐ Wire(s)
6 ☐ Pole(s)
7 ☐ Tree(s)
8 ☐ Tower(s)
9 ☐ Dirt bank
10 ☐ Snow bank
11 ☐ Ditch
12 ☐ Water
13 ☐ Vertical drop
14 ☐ High terrain
A Other

Airport/Airstrip Facilities

(Complete only those items which are pertinent to the accident/incident)	A Installed 1 Yes	A Installed 2 No	B Functioning 1 Yes	B Functioning 2 No	C Used 1 Yes	C Used 2 No	D Other
18 VASI/VAPI							
19 Wind Direction Indicator							
20 Landing Direction Indicator							
21 Low Level Wind Shear Alert System							
22 Runway Barrier							
23 Runway Remaining Markers							
24 Tower							
25 UNICOM							
26 FSS							
27 ATIS							

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Supplement Q—Airport/Airstrip (continued)

Airport/Airstrip Facilities *(Night or IMC)*
If the accident/incident occurred during approach, departure or on airport and it was night or IMC—complete those items which are considered pertinent to the occurrence.

Airport/Airstrip Facilities	A Installed 1 Yes	A Installed 2 No	B Functioning 1 Yes	B Functioning 2 No	C Other
31 (ILS) Instrument Landing System—Complete					
32 ILS—Localizer Only					
33 ILS—Backcourse					
34 (MLS) Microwave Landing System					
35 VOR/TVOR					
36 VORTAC					
37 TACAN					
38 DME					
39 NDB					
40 (LOM) Locator Outer Marker					
41 Middle Marker					
42 Lighted Wind Indicator					
43 Approach Lights—Ground Actuated					
44 Approach Lights—Pilot Actuated					
45 Touchdown Zone Lights					
46 Threshold Lights					
47 Runway End Identifier Lights (REIL)					
48 Runway Edge Lights					
49 Runway Centerline Lights					
50 Taxiway Edge Lights					
51 Taxiway Centerline Lights					
52 Rotating Beacon					

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Supplement Q—Airport/Airstrip (continued)

55 Type Approach Lights *(Runway used)*
1 ☐ ALSF-1
2 ☐ ALSF-2
3 ☐ SSALF
4 ☐ SSALR
5 ☐ MALSF
6 ☐ MALSR
7 ☐ LDIN
8 ☐ RAIL
9 ☐ ODALS
A Other

56 Type VASI *(Runway used)*
1 ☐ 2-bar
2 ☐ 3-bar
3 ☐ Tri-color
4 ☐ T-VASI
5 ☐ PLASI
A Other

57 Type Runway Edge Lights *(Runway used)*
1 ☐ LIRL
2 ☐ MIRL
3 ☐ HIRL
A Other

58 Runway Lights—Intensity/Setting
1 ☐ Low intensity
2 ☐ Medium
3 ☐ High
A Other

59 Point Where Aircraft Left Runway/Landing Surface *(Multiple entry)*
1 ☐ Approach end
2 ☐ Departure end
3 ☐ Left side
4 ☐ Right side
5 ☐ None
A Other

60 Departed Runway, Distance from Threshold
_____ Feet
A Other

61 Type of Ground Contact on Runway Landing Surface
1 ☐ Touchdown
2 ☐ Impact
A Other

62 Point of Ground Contact
1 ☐ Approach end
2 ☐ Departure end

63 Ground Contact, Distance from Threshold
_____ Feet
A Other

64 Ground Contact, Bearing from Threshold
_____ Degrees magnetic
A Other

65 Point Where Aircraft Came to Rest, Distance From Runway Threshold
1 ☐ Approach end
2 ☐ Departure end
A _____ Feet
B Other

66 Point Where Aircraft Came to Rest, Relative Bearing from Runway Heading
_____ deg.
A Other

67 Runway Profile
1 ☐ Level
2 ☐ Up
3 ☐ Down
4 ☐ Down-up
5 ☐ Up-down
A Other

68 Average Slope Up
_____ Percent grade
A Other

69 Average Slope Down
_____ Percent grade
A Other

This section to be completed for all accidents/incidents occurring during takeoff, approach or landing at a limited or full certification airport.

70 Runway RCR Recorded
1 ☐ No
A Yes-reading _____
B Other

71 Runway Friction Measuring Equipment
1 ☐ Available-used
2 ☐ Available not used
3 ☐ Not available
A Other

72 Type of Runway Friction Measuring Equipment
1 ☐ JBD
2 ☐ DBV
3 ☐ Friction meter
4 ☐ Mess-fix
5 ☐ Pilot
6 ☐ Vehicle
7 ☐ Skidmeter
8 ☐ Tapley meter
9 ☐ Mu-meter
10 ☐ Estimate
A Other

73 Braking Action Report
1 ☐ No report
2 ☐ Good
3 ☐ Fair
4 ☐ Poor
5 ☐ Nil
A Other

74 Pilot Aware of Braking Action NOTAM
1 ☐ Yes
2 ☐ No
A Other

National Transportation Safety Board

FACTUAL REPORT
AVIATION

Supplement R—Meteorology

Complete this supplement for any accident in which weather conditions were considered a factor **and** *an on-scene investigation was conducted.*

1 Turbulence Forecast
1 ☐ Yes
2 ☐ No *(Go to block 5)*

2 Severity of Forecast Turbulence
1 ☐ Light
2 ☐ Moderate
3 ☐ Severe
4 ☐ Extreme
A Other

3 Type of Forecast Turbulence
1 ☐ In clouds
2 ☐ In thunderstorm
3 ☐ Clear air
4 ☐ Mountain wave
A Other

4 Icing Forecast
1 ☐ Yes
2 ☐ No *(Go to block 8)*

5 Severity of Forecast Icing
1 ☐ Trace
2 ☐ Light
3 ☐ Moderate
4 ☐ Severe
A Other

6 Type of Forecast Icing
1 ☐ Rime
2 ☐ Clear
3 ☐ Mixed
A Other

7 Thunderstorm Forecast
1 ☐ Yes
2 ☐ No *(Go to block 10)*

8 Level of Forecast Thunderstorm
1 ☐ Severe
2 ☐ Not severe
A Other

9 In-flight Weather Service Available
1 ☐ Yes
2 ☐ No
A Other

10 In-flight Weather Service Used
1 ☐ Yes
2 ☐ No
A Other

11 Type of In-flight Weather Service Used *(Multiple entry)*
1 ☐ ATC
2 ☐ FSS
3 ☐ ATIS
4 ☐ TIWEB
5 ☐ EFAS
6 ☐ Company weather
7 ☐ Contract weather
8 ☐ VOR
A Other

Weather Conditions At Accident Site

If weather information entered on Form 6120.4 is based upon pilot/witness only, enter meteorological information from closest/most pertinent weather observation facility. Otherwise proceed to block 25.

12 Weather Observation Facility *(Direct entry)*
A Identifier _____
B Time of observation _____ zone _____
C Elevation _____ feet MSL
D Distance from accident site _____ NM
E Direction from accident site _____ magnetic

13 Sky/Lowest Cloud Condition *(Multiple entry)*
1 ☐ Clear
2 ☐ Scattered
3 ☐ Thin broken
4 ☐ Thin overcast
5 ☐ Partial obscuration
A _____ Feet AGL
B Other

14 Lowest Ceiling *(Multiple entry)*
1 ☐ None
2 ☐ Broken
3 ☐ Overcast
4 ☐ Obscured
A _____ Feet AGL
B Other

15 Visibility *(decimals)*
A _____ SM
B RVR _____ Feet
C RVV _____ SM
D Other

16 Temperature
_____ °F
A Other

17 Dew Point
_____ °F
A Other

18 Wind Direction *(From)*
1 ☐ Variable
A ____ magnetic
B Other

19 Wind Speed *(Multiple entry)*
1 ☐ Calm
2 ☐ Light and Variable
A _____ Knots
B _____ *(Gusts)* Knots
C Other

20 Altimeter Setting
A _____ "Hg
B Other

21 Density Altitude
_____ Feet
A Other

22 Type of Precipitation *(Multiple entry)*
1 ☐ None *(Go to block 25)*
2 ☐ Rain (R)
3 ☐ Snow (S)
4 ☐ Hail (A)
5 ☐ Rain showers (RW)
6 ☐ Freezing rain (ZR)
7 ☐ Snow shower (SW)
8 ☐ Drizzle (L)
9 ☐ Ice pellets (IP)
10 ☐ Snow pellets (SP)
11 ☐ Snow grains (SG)
12 ☐ Freezing drizzle (ZL)
13 ☐ Ice crystals (IC)
14 ☐ Ice pellet shower (IPW)
A Other

23 Intensity of Precipitation
1 ☐ Light
2 ☐ Moderate
3 ☐ Heavy
A Other

24 Restrictions to visibility *(Multiple entry)*
1 ☐ None
2 ☐ Haze (H)
3 ☐ Dust (D)
4 ☐ Smoke (K)
5 ☐ Fog (F)
6 ☐ Ice fog (IF)
7 ☐ Ground fog (GF)
8 ☐ Blowing spray (BY)
9 ☐ Blowing dust (BD)
10 ☐ Blowing snow (BS)
11 ☐ Blowing Sand (BN)
A Other

National Transportation Safety Board

FACTUAL REPORT
AVIATION

Supplement R—Meteorology (continued)

Turbulence/Icing/Thunderstorms/Other Significant Weather

25 Turbulence *(Multiple entry)*
- 1 ☐ None
- 2 ☐ In clouds
- 3 ☐ In thunderstorms
- 4 ☐ Clear air
- 5 ☐ Mountain wave
- A Other

26 Severity of Turbulence
- 1 ☐ Light
- 2 ☐ Moderate
- 3 ☐ Severe
- 4 ☐ Extreme
- A Other

27 Source of Turbulence Information
- 1 ☐ National Weather Service (NWS)
- 2 ☐ Weather analysis
- A Pilot report *(Aircraft type* _____ *)*
- B Other

28 Type of Icing Conditions That Existed *(Multiple entry)*
- 1 ☐ None
- 2 ☐ Frost
- 3 ☐ Rime *(Glaze)*
- 4 ☐ Clear
- 5 ☐ Mixed
- A Other

29 Severity of Icing Conditions
- 1 ☐ Trace
- 2 ☐ Light
- 3 ☐ Moderate
- 4 ☐ Severe
- A Other

30 Source of Icing Condition Information
- 1 ☐ National Weather Service (NWS)
- 2 ☐ Weather analysis
- A Pilot report *(Aircraft type* _____ *)*
- B Other

31 Thunderstorm Activity Observed
- 1 ☐ None
- 2 ☐ Level 1 *(Light)*
- 3 ☐ Level 2 *(Moderate)*
- 4 ☐ Level 3 *(Heavy)*
- 5 ☐ Level 4 *(Very heavy)*
- 6 ☐ Level 5 *(Intense)*
- 7 ☐ Level 6 *(Extreme)*
- A Other

32 Source of Thunderstorm Information
- 1 ☐ NWS
- 2 ☐ Witness
- 3 ☐ Weather analysis
- A Pilot report *(Aircraft type* _____ *)*
- B Other

33 Other Significant Weather *(Multiple entry)*
- 1 ☐ None
- 2 ☐ Tornado
- 3 ☐ Wind shear
- 4 ☐ Frontal system
- 5 ☐ Inversion
- 6 ☐ Water spout
- 7 ☐ Hurricane
- 8 ☐ Funnel cloud
- 9 ☐ Squall line
- 10 ☐ Updraft
- 11 ☐ Downdraft
- 12 ☐ Variable cloud base
- 13 ☐ Whirlwind/dust devil
- 14 ☐ Mountain wave
- A Other

34 Pertinent Weather Message Issued *(Multiple entry)*
- 1 ☐ AIRMET
- 2 ☐ SIGMET
- 3 ☐ Center Weather Advisory (CWA)
- 4 ☐ Convective SIGMET
- A Other

35 Pilot Aware of Significant Weather *(Multiple entry)*
- 1 ☐ Turbulence
- 2 ☐ Icing
- 3 ☐ Thunderstorm
- 4 ☐ Other significant weather
- 5 ☐ No
- A Other

36 Pilot's Source of Information *(Multiple entry)*
- 1 ☐ Briefing
- 2 ☐ In-flight advisories (AIRMET, SIGMET, etc.)
- 3 ☐ ATC
- 4 ☐ Pilot observation
- 5 ☐ Weather radar
- 6 ☐ Storm scope
- A Other

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Supplement S—Aircraft Occupant and Injured Ground Personnel

Other Occupants							H Degree of Injury			
A Name	B Seat No.	C Address (City & State)	D Crew	E Passenger	F Non-Occupant	G FAA	4 Fatal	3 Serious	2 Minor	1 None
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Supplement S—Aircraft Occupant and Injured Ground Personnel (continued)

Other Occupants	B	C	D	E	F	G	H Degree of Injury			
A Name	Seat No.	Address (City & State)	Crew	Passenger	Non-Occupant	FAA	4 Fatal	3 Serious	2 Minor	1 None

National Transportation Safety Board

FACTUAL REPORT AVIATION

NTSB Accident/Incident Number

Supplement T—Flight Data Recorder (FDR) Cockpit Voice Recorder (CVR)

Flight Data Recorder

1 Flight Data Recorder (FDR) Installed

1 ☐ Yes-recovered
2 ☐ Yes-not recovered
3 ☐ No
A Other

2 Flight Recorder Manufacturer

A Other

3 Flight Recorder—Model No.

A Other

4 Flight Data Recorder Condition

1 ☐ Destroyed-fire
2 ☐ Destroyed-impact
3 ☐ Damaged-fire
4 ☐ Damaged-impact
5 ☐ Undamaged
A Other

5 Flight Data Recorder Source of Damage *(Multiple entry)*

1 ☐ Fire
2 ☐ Impact
A Other

6 Recording Medium Condition *(Multiple entry)*

1 ☐ Not damaged by occurrence
2 ☐ Destroyed by impact
3 ☐ Destroyed by fire
4 ☐ Damaged by impact
5 ☐ Damaged by fire
6 ☐ Damaged by mishandling
A Other

7 Data Recovery Status

1 ☐ All parameters recovered
2 ☐ Partial loss—impact/fire damage
3 ☐ Partial loss—preoccurrence recorder malfunction
4 ☐ Partial loss due to mishandling
5 ☐ Complete loss—preoccurrence allied system malfunction
6 ☐ Complete loss—preoccurrence recorder malfunction
7 ☐ Complete loss due to mishandling
8 ☐ Foil medium expended prior to occurrence
9 ☐ Occurrence prior to oldest recorded data
10 ☐ No data recovered
A Other

Cockpit Voice Recorder

8 Cockpit Voice Recorder (CVR) Installed

1 ☐ Yes-recovered
2 ☐ Yes-not recovered
3 ☐ No
A Other

9 Cockpit Voice Recorder Manufacturer

A Other

10 Cockpit Voice Recorder Model No.

A Other

11 Cockpit Voice Recorder Condition

1 ☐ Destroyed-fire
2 ☐ Destroyed-impact
3 ☐ Damaged-fire
4 ☐ Damaged-impact
5 ☐ Undamaged
A Other

12 CVR Component Condition

1 ☐ Pinger operable
2 ☐ Pinger inoperable
A Other

13 Recording Medium Condition

1 ☐ Destroyed
2 ☐ Damaged
3 ☐ Undamaged
A Other

14 CAM Recording Quality

1 ☐ Excellent
2 ☐ Satisfactory
3 ☐ Unsatisfactory
4 ☐ Unreadable
A Other

15 RDO Quality of Recording

1 ☐ Excellent
2 ☐ Satisfactory
3 ☐ Unsatisfactory
4 ☐ Unreadable
A Other

16 Recording Medium Quality Loss Source

1 ☐ None
2 ☐ Fire
3 ☐ Mechanical
4 ☐ Electrical
5 ☐ Maintenance and engineering
A Other

17 CVR Quality Loss Source

1 ☐ None
2 ☐ Fire
3 ☐ Mechanical
4 ☐ Electrical
5 ☐ Maintenance and engineering
A Other

18 Additional Recording Media Received *(Multiple entry)*

1 ☐ CVR
2 ☐ Tower
3 ☐ Center
4 ☐ ATC
5 ☐ Personal recorder
6 ☐ TV recorder
7 ☐ Commercial radio
8 ☐ Commercial TV
9 ☐ Motion picture film
A Other

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Supplement U—Crew Information FAR 121, 125, 127, 135 Operations

Pilot In Command Additional Flight/Duty/Rest Time Information

	A	B Flight Time	C	D	E Duty Time	F	G	H Rest Period	I	J Time Zone Changes	K
1 Day of Accident	Hrs	Mins	Other	Hrs.	Mins	Other	Hrs.	Mins.	Other		Other
2 Day 2	Hrs	Mins.	Other	Hrs	Mins	Other	Hrs	Mins.	Other		Other
3 Day 3	Hrs	Mins	Other	Hrs	Mins	Other	Hrs	Mins.	Other		Other
4 Day 4	Hrs.	Mins.	Other	Hrs.	Mins	Other	Hrs	Mins.	Other		Other
5 Day 5	Hrs.	Mins	Other	Hrs	Mins	Other	Hrs	Mins	Other		Other
6 Day 6	Hrs	Mins	Other	Hrs	Mins	Other	Hrs.	Mins.	Other		Other
7 Day 7	Hrs.	Mins	Other	Hrs.	Mins	Other	Hrs	Mins.	Other		Other

8 Method of Payment *(Multiple entry)*
- 1 ☐ Salary
- 2 ☐ By flight hour
- 3 ☐ By duty hour
- 4 ☐ By completed trip
- A Other

9 Bonus For Speed
- 1 ☐ Yes
- 2 ☐ No
- A Other

10 Bonus For Completion *(Multiple entry)*
- 1 ☐ None
- 2 ☐ Trip
- 3 ☐ Flight
- A Other

Copilot Additional Flight/Duty/Rest Time Information

11 ☐ None *(Go to block 25)*

	A	B Flight Time	C	D	E Duty Time	F	G	H Rest Period	I	J Time Zone Changes	K
13 Day of Accident	Hrs.	Mins.	Other	Hrs.	Mins	Other	Hrs.	Mins.	Other		Other
14 Day 2	Hrs.	Mins.	Other	Hrs	Mins.	Other	Hrs.	Mins.	Other		Other
15 Day 3	Hrs.	Mins.	Other	Hrs	Mins.	Other	Hrs.	Mins.	Other		Other
16 Day 4	Hrs.	Mins.	Other	Hrs.	Mins.	Other	Hrs.	Mins.	Other		Other
17 Day 5	Hrs.	Mins.	Other	Hrs.	Mins.	Other	Hrs	Mins.	Other		Other
18 Day 6	Hrs.	Mins.	Other	Hrs.	Mins	Other	Hrs	Mins.	Other		Other
19 Day 7	Hrs.	Mins.	Other	Hrs.	Mins.	Other	Hrs.	Mins.	Other		Other

20 Method of Payment *(Multiple entry)*
- 1 ☐ Salary
- 2 ☐ By flight hour
- 3 ☐ By duty hour
- 4 ☐ By completed trip
- A Other

21 Bonus For Speed
- 1 ☐ Yes
- 2 ☐ No
- A Other

22 Bonus For Completion *(Multiple entry)*
- 1 ☐ None
- 2 ☐ Trip
- 3 ☐ Flight
- A Other

National Transportation Safety Board

FACTUAL REPORT AVIATION

NTSB Accident/Incident Number

Supplement U—Crew Information FAR 121, 125, 127, 135 Operations (continued)

Flight Engineer Information

25 ☐ None on Aircraft *(Go to Flight Attendant Information)*

26 Certificate(s) *(Multiple entry)*
1 ☐ Private
2 ☐ Commercial
Flight Engineer
5 ☐ Reciprocating
6 ☐ Turbopropeller
7 ☐ Turbojet
3 ☐ Airline transport
4 ☐ Flight instructor
8 ☐ Foreign
9 ☐ Military
10 ☐ None
A Other

27 Airplane Ratings *(Multiple entry)*
1 ☐ None
2 ☐ SE land
3 ☐ ME land
4 ☐ SE sea
5 ☐ ME sea

28 Rotorcraft/Glider *(Multiple entry)*
1 ☐ None
2 ☐ Helicopter
3 ☐ Gyroplane
4 ☐ Glider
5 ☐ Airship
6 ☐ Free balloon

29 Instrument Rating(s) *(Multiple entry)*
1 ☐ None
2 ☐ Airplane
3 ☐ Helicopter

30 Type Rating
1 ☐ Yes
2 ☐ No

31 Total Engineer Flight Time
_____ Hrs
A Other

32 Engineer Time in Type Aircraft
_____ Hrs.
A Other

33 Engineer Time Last 90 Days
_____ Hrs
A Other

34 Engineer Time Last 30 Days
_____ Hrs
A Other

35 Medical Certificate Validity
1 ☐ Valid medical-no waivers/limitations
2 ☐ Valid medical-with waivers/limitations
3 ☐ Non valid medical for this flight
4 ☐ Expired certificate
5 ☐ No medical certificate
A Other

36 Medical Limitation
1 ☐ None
2 ☐ Vision
A Specify _____
B Other

37 Medical Waiver
1 ☐ None
2 ☐ Vision
3 ☐ Hearing
A Specify _____
B Other

38 Medical Certificate
1 ☐ None
2 ☐ Class 1
3 ☐ Class 2
4 ☐ Class 3
A Other

39 Date of Last Medical *(Nos. for M. D. Y)*
_____
A Other

	Flight Time			Duty Time			Rest Period			Time Zone	
	A	B	C	D	E	F	G	H	I	J Changes	K
42 Day of Accident	Hrs.	Mins	Other	Hrs.	Mins.	Other	Hrs.	Mins.	Other		Other
43 Day 2	Hrs.	Mins.	Other	Hrs.	Mins.	Other	Hrs.	Mins.	Other		Other
44 Day 3	Hrs.	Mins.	Other	Hrs.	Mins.	Other	Hrs.	Mins.	Other		Other
45 Day 4	Hrs.	Mins.	Other	Hrs.	Mins.	Other	Hrs.	Mins.	Other		Other
46 Day 5	Hrs.	Mins.	Other	Hrs.	Mins.	Other	Hrs.	Mins.	Other		Other
47 Day 6	Hrs.	Mins.	Other	Hrs.	Mins.	Other	Hrs.	Mins.	Other		Other
48 Day 7	Hrs.	Mins.	Other	Hrs.	Mins.	Other	Hrs.	Mins.	Other		Other

Flight Attendant Information

51 ☐ None on Aircraft *(Go to block 57)*

52 Date Hired *(Nos. for M. D. Y)*

A	B	C	D	E
F	G	H	I	J
K	L	M	N	

National Transportation Safety Board

FACTUAL REPORT AVIATION

NTSB Accident/Incident Number

Supplement U—Crew Information FAR 121, 125, 127, 135 Operations (continued)

Flight Attendant Information (continued)

53 Date Qualified In Position	A	B	C	D	E
	F	G	H	I	J
	K	L	M	N	
54 Date Of Current Training	A	B	C	D	E
	F	G	H	I	J
	K	L	M	N	

CFR 121, 127 Training and Flight Checks

	Date Completed (Nos. for M. D. Y)			Hours Completed		
	PIC/Captain A	Copilot B	Flight Eng C	PIC/Captain D	Copilot E	Flight Eng F
57 Emergency						
58 Hazardous Materials						
59 Initial Ground						
60 Initial Flight						
61 Recurrent Ground						
62 Recurrent Flight						
63 Simulator						
64 Line Check						
65 Proficiency Check						
66 Route/Airport Qual.						
67 Date Hired						
68 Date Qual. In Position						
69 Current In Other Aircraft	1 ☐ Yes	1 ☐ Yes	1 ☐ Yes			
	2 ☐ No	2 ☐ No	2 ☐ No			

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB Accident/Incident Number

Supplement U—Crew Information FAR 121, 125, 127, 135 Operations

CFR 125, 135 Training and Flight Checks

	Date Completed (Nos. for M. D. Y)			Hours Completed		
	A PIC/Captain	B Copilot	C Flight Eng.	D PIC/Captain	E Copilot	F Flight Eng.
72 Date Hired						
73 Date Qualified in Position						
74 Competency Flight Check						
75 Instrument Proficiency Flight Check						
76 Current in Other Aircraft	1 ☐ Yes	1 ☐ Yes	1 ☐ Yes			
	2 ☐ No	2 ☐ No	2 ☐ No			

FAA Surveillance of Air Taxi Operators

79 Type of FAA Office (Multiple entry)

1 ☐ GADO
2 ☐ FSDO
3 ☐ ACDO
A Other

80 Date Certificate Issued (Nos. for M. D. Y)

A Other

	A District Office	B POI	C PMI
81 Date Last Base Inspection Conducted (Accident Operator) (Nos. for M. D. Y)			
82 No. of Enroute Checks Last Year (Accident Operator)			

APPENDIX 2

CASB Report Of Investigation
Of An Aircraft Accident/Incident

Canadian Aviation Safety Board — Bureau canadien de la sécurité aérienne

REPORT OF INVESTIGATION OF AN AIRCRAFT

FILE NUMBER
AIRCRAFT REGISTRATION 0102

☐ A ACCIDENT 0101 ☐ I INCIDENT

LOCATION OF OCCURRENCE 0103	PROVINCE 0104	REGION 0105

LATITUDE 0106	LONGITUDE 0107	DATE 0108 DAY MONTH YEAR	TIME (LOCAL) 0109

LIGHT CONDITIONS AT SITE 0110						
	A	DAWN	C	DUSK (TWILIGHT)	E	NIGHT (BRIGHT)
	B	DAYLIGHT	D	NIGHT (DARK)		

PERSONNEL IDENTIFICATION

REGISTERED OWNER	NAME	ADDRESS
OPERATOR	NAME — A 0113 SAME AS OWNER — OR	CIRCLE THE ATC LICENCE CLASSIFICATION PERTINENT TO THIS FLIGHT 0111 2010
	ADDRESS	NONE 1 2 3 4 5 6 7RF 7FT 7AP 7APS 7AAD 7AIRA 7AC 7ACONST 8 9-2 9-3 9-4 9-5
	ATC LICENCE NUMBER	OPERATOR CODE (HQ Use) 0118
	WAS A SUITABLE ATC LICENCE HELD FOR THE OPERATION? 2011	Y YES; N NOT REQUIRED; X NO; Z UNKNOWN
	STATUS RESPECTIVE TO THIS AIRCRAFT 0112	B RENTER; C LESSEE; D BORROWER; Z UNKNOWN
	TYPE OF OPERATOR 0114	A FLYING SCHOOL; M FLYING CLUB; N SCHEDULED; D CHARTER; F FBO-SALES/SERVICES/RENTAL; O PRIVATE OWNER; I STATE – MUNICIPAL; B CORPORATE/EXECUTIVE; E AIR TAXI; H STATE – PROVINCIAL; K A/C MANUFACTURER; Y OTHER; G STATE – FEDERAL; C AERIAL WORK
PILOT IN COMMAND 0115	NAME — SAME AS: A OWNER; B OPERATOR — OR	STATUS IF NOT OWNER OR OPERATOR 0117
	ADDRESS	C UNAUTHORIZED USER; F EMPLOYEE; D RENTER; G BORROWER; E CLUB MEMBER
	LICENCE NUMBER 0116	Y OTHER

MATERIAL IDENTIFICATION

AIRCRAFT	MANUFACTURER 0119	MODEL 0119	SERIAL NUMBER 0120	MAX T/O WEIGHT 0121	YEAR OF MANUFACTURE 0122

AIRCRAFT CLASSIFICATION 0123 0124								
	A	AEROPLANE	I	GYROPLANE	F	DIRIGIBLE	H	HOMEBUILT
	B	HELICOPTER	D	BALLOON	E	BLIMP	U	ULTRA-LIGHT
	C	GLIDER	Y	OTHER	J	POWERED GLIDER	B	BOTH
							Y	OTHER

LANDING GEAR 0125								
	1	H	TRICYCLE FIXED	G	TAILWHEEL RETRACT	D	SKI	
		F	TRICYCLE RETRACT	B	HULL/FLOAT	E	SKID	
		I	TAILWHEEL FIXED	C	AMPHIBIOUS			
	2	A	HULL — B FLOAT	C	SKI-WHEEL	D	FLOAT-SKID	E BLOW-OUT FLOAT

WING/ROTOR 0127							
	A	LOW WING	C	MID WING	E	TWIN ROTOR	F BIPLANE
	B	HIGH WING	D	SINGLE ROTOR	Y	OTHER	

SPECIAL EQUIPMENT 0128							
	A	TOWING GEAR	D	AMBULANCE	G	AIR DROP (CARGO)	K AIR DROP (PARACHUTIST)
	B	PHOTO	E	GEOPHYSICAL SURVEY	H	SLING/HOIST	L WATER BOMBING
	C	AERIAL APPLICATION	F	MONSOON BUCKET	M	ADVERTISING	Y OTHER

MATERIAL IDENTIFICATION (CONT'D)

ENGINE(S)	MANUFACTURER 0201		MODEL 0202		NUMBER INSTALLED 0203	RATED POWER 0204		HP. / lbs THRUST
SERIAL NUMBERS	1		2		3		4	
ENGINE TYPE 0205	A	RECIPROCATING	F	TURBOSHAFT (HELICOPTERS)	B	TURBOJET	E	NONE
	C	TURBOPROP	D	TURBOFAN	Y	OTHER		
PROPELLER(S)/ ROTOR BLADES	MANUFACTURER 0206		MODEL 0207		SERIAL NOS	(1)	(2)	
						(3)	(4)	
PROPELLER TYPE 0208 0209	A	FIXED METAL	C	VARIABLE PITCH	E	FIXED WOODEN	R	REVERSIBLE
	B	CONSTANT SPEED	D	CONSTANT SPEED FULLY FEATHERING	Y	OTHER	F	FLAT PITCH
ROTOR SYSTEM 0210	A	RIGID	D	HINGELESS	G	VARIABLE DIAMETER		
	B	SEMI-RIGID	E	GIMBALLED	H	CONTROLLABLE		
	C	FULLY ARTICULATED	F	VARIABLE GEOMETRY	K	FULLY INTEGRATED PROPULSION SYSTEMS		

HISTORY OF THE FLIGHT

OPERATION GENERAL AVIATION 0211	INSTRUCTIONAL	A2	DUAL	A1	SUPERVISED SOLO	A2	CHECK	A3	TRAINING (EXCEPT AIR CARRIER)
	GENERAL	B0	PLEASURE	B3	BUSINESS-PROFESSIONAL PILOT			B2	BUSINESS—NON-PROFESSIONAL PILOT
		BI	PRACTICE	BY	OTHER				
		CA	AERIAL APPLICATION	CB	ASSOCIATED CROP CONTROL ACTIVITIES			CC	FIRE CONTROL
		CE	AERIAL SURVEY	CF	AERIAL ADVERTISING			CD	ASSOCIATED FIRE CONTROL ACTIVITIES
		CG	POWER/PIPELINE PATROL	CH	AERIAL SPOTTING (OVER WATER)			CK	CONSTRUCTION (ROTORCRAFT)
		CW	AERIAL PHOTOGRAPHY	CX	AERIAL AMBULANCE				
	MISCELLANEOUS	DA	EXPERIMENTAL	DC	DEMONSTRATION			DB	TEST
		DD	FERRY	DY	OTHER				
OPERATION AIR TRANSPORT 0240			DOMESTIC		SCHEDULED		PASSENGER		OTHER
			INTERNATIONAL		NON-SCHEDULED		CARGO		TRAINING
LOAD DESCRIPTION 0212	A	NONE	E	PARACHUTIST(S)	K	PHOTO EQUIPMENT		P	SIGN/DROGUE
	B	PASSENGERS	F	PESTICIDES	L	FERTILIZER		Q	GLIDER
	C	CARGO	G	POLES/TOWERS	M	FISH/FISH EGGS		Y	OTHER
	D	CARGO & PASSENGERS	H	WATER/CHEMICAL	N	POTENTIALLY DANGEROUS CARGO			
LOAD POSITION 0213			A	INTERNAL	B	EXTERNAL		C	NONE

LAST DEPARTURE POINT 0214	POINT OF INTENDED LANDING 0215
FIRST OR ONLY PHASE OF OPERATION 0216	FIRST OR ONLY TYPE OF OCCURRENCE 0217
SECOND PHASE OF OPERATION (IF APPLICABLE) 0218	SECOND TYPE OF OCCURRENCE (IF APPLICABLE) 0219

PRELIMINARY VERSION OF OCCURRENCE

0220 AIRCRAFT DAMAGE	N	NONE	M	MINOR	S	SUBSTANTIAL	D	DESTROYED	Z	UNKNOWN
DAMAGE TO OTHER PROPERTY 0262	A	SCHOOL	B	HOUSE(S)	F	COMMERCIAL BUILDING	C	CHURCH		
	E	OFFICE BUILDING	D	APARTMENT(S)	G	SHOPPING CENTRE	Y	OTHER		
MILITARY INVOLVEMENT 0261	Y	YES	X	NO						

HISTORY OF THE FLIGHT (CONT'D)

TYPE OF FLIGHT PLAN 0301/0302	H	NONE	A	IFR	F	FLIGHT NOTIFICATION FILED	B	CONTROLLED VFR	Y	OTHER
	E	VFR	D	SPECIAL VFR	B	FLIGHT NOTIFICATION VERBAL	C	DEFENCE VFR	Z	UNKNOWN
TYPE OF CLEARANCE		NONE		TAXI		APPROACH/ DEPARTURE		LANDING		ENROUTE
AERONAUTICAL DEPARTURE BRIEFING 0303	1	AIS AVAILABLE & USED - INFORMATION VALID			3	AIS AVAILABLE AND NOT USED				
	2	AIS AVAILABLE & USED - INFORMATION INVALID			4	AIS NOT AVAILABLE				

DURATION OF FLIGHT	AIRCRAFT SPEED		ALTITUDE OF OCCURRENCE (AGL)	COLLISION OR NEAR COLLISION	
	AT TIME OF OCCURRENCE IN FLIGHT	AT IMPACT		REGISTRATION OF OTHER AIRCRAFT	EVASIVE ACTION TAKEN 0309
HR MIN. 0304	0305 X1	0306 X1	0307 0401	0308	YES / NO / UNK

AIRSPACE SEGMENT	E	UNCONTROLLED AIRSPACE	P	APRON, PARKING AREA	K	HOLDING AREA
	H	CONTROLLED AIRSPACE	C	CONTROL ZONE	N	RUNWAY, TAXIWAY
	B	CONTROL AREA	J	INITIAL APPROACH AREA	Y	OTHER
	G	ADVISORY AIRSPACE	L	INTERMEDIATE APPROACH AREA		
0310	I	ADVISORY AREA	M	FINAL APPROACH AREA		
EMERGENCY CIRCUMSTANCES (Select up to 2)	A	LOW ON FUEL	M	AIRFRAME BUFFET/VIBRATION	C	PASSENGER DISTURBANCE
	D	FIRE WARNING	H	UNUSUAL NOISE	P	PHYSICAL CONDITION OF OCCUPANT (NOT FLIGHT CREW)
	E	LATERAL CONTROL PROBLEM	R	PROP/ENGINE VIBRATION	B	UNLAWFUL INTERFERENCE (HIJACKING, SABOTAGE)
	F	PITCH CONTROL PROBLEM	T	LANDING GEAR MALFUNCTION	U	PHYSICAL CONDITION OF FLIGHT CREW
	G	DIRECTIONAL CONTROL PROBLEM	V	PRESSURIZATION PROBLEM	H	WEATHER ADVERSE/UNFAVOURABLE
	J	AIRCRAFT DAMAGE SUSPECTED OR KNOWN	X	KNOWN OR SUSPECTED REDUCED AIRCRAFT PERFORMANCE	I	VISUAL & LIGHT CONDITIONS
	K	MECHANICAL DISCREPANCY SUSPECTED OR KNOWN	S	SMOKE INSIDE AIRCRAFT	Y	OTHER
0311	L	DOOR/PANEL OPEN	Q	FUMES INSIDE AIRCRAFT		
FORCED LANDING-PRECAUTIONARY LANDING 0312	A	F.L. ON AERODROME/HELIPORT	B	F.L. OFF AERODROME ON LAND	C	DITCHING
	D	F.L. ON AERODROME	E	F.L. OFF AERODROME		
TYPE OF APPROACH FLOWN	E	NDB STRAIGHT-IN	G	ILS RADAR MONITOR STRAIGHT-IN	3	ILS CAT I OR ABOVE MANUAL CONTROL
	F	NDB CIRCLING	H	ILS RADAR MONITOR CIRCLING	5	ILS CAT I AUTOPILOT CONTROL
	C	VOR STRAIGHT-IN	I	ILS STRAIGHT-IN	6	ILS CAT II AUTOPILOT CONTROL
	D	VOR CIRCLING	J	ILS CIRCLING	4	ILS CAT II MANUAL CONTROL
	X	VORTAC	K	LOC BCRS STRAIGHT-IN	7	ILS CAT III AUTOLANDING
	P	SURVEILLANCE RADAR STRAIGHT-IN	L	LOC BCRS CIRCLING	R	VISUAL STRAIGHT-IN
	Q	SURVEILLANCE RADAR CIRCLING	I	LOC FRONT CRS STRAIGHT-IN	S	VISUAL FULL CIRCUIT
0313	T	PAR STRAIGHT-IN	J	LOC FRONT CRS CIRCLING	Y	OTHER

INJURY INDEX 0314	F	FATAL	C	SERIOUS	M	MINOR	N	NONE

		FATAL	SERIOUS	MINOR	NONE	UNKNOWN	TOTALS
INJURIES TO PERSONS	PILOT IN COMMAND	0221	0222	0223	0224	0225	0226
	OTHER CREW	0227	0228	0229	0230	0231	0232
	CO-PILOT	0318	0319	0317	0318	0319	0320
	DUAL STUDENT	0321	0322	0323	0324	0325	0326
	SUPERVISORY PILOT	0327	0328	0329	0330	0331	0332
	FLIGHT ENGINEER/ SYSTEMS OPERATOR	0333	0334	0335	0336	0337	0338
	NAVIGATOR/RADIO OPERATOR	0339	0340	0341	0342	0343	0344
	CABIN CREW	0345	0346	0347	0348	0349	0350
	SUPERNUMERARY CREW	0351	0352	0353	0354	0355	0356
	PASSENGERS	0333	0334	0335	0336	0337	0338
	TOTAL ABOARD	0357	0358	0359	0360	0361	0362
	OTHER (AIRCRAFT)	0363	0364	0365			0366
	OTHER (GROUND)	0368	0370	0371			0374
	TOTALS	0375	0376	0377	0378	0379	0380

ELEVATION VIEW OF LOCALE

SKETCH IN SIGNIFICANT RUNWAY, OBSTRUCTIONS, FLIGHT PATH ETC. SHOW IMPORTANT DISTANCES & DIMENSIONS

PLAN VIEW OF LOCALE

SKETCH IN SIGNIFICANT LANDING AREA, OBSTRUCTIONS, AIRCRAFT PATH ETC. SHOW IMPORTANT DISTANCES & DIMENSIONS, AND THE WIND VECTOR.

PERSONNEL INFORMATION – PILOT

PILOT AT CONTROLS 0901						
	A	PILOT-IN-COMMAND	G	INSTRUCTOR	E	NONE
	B	CO-PILOT	D	SUPERVISORY PILOT	Y	OTHER
	C	STUDENT	F	BOTH PILOTS		

PILOT IN COMMAND

AGE 0902	SEX 0903		SURNAME	INITIALS	LICENCE NUMBER 0906/0907	CREWMEMBER NATIONALITY 0907		
	M	F					C	CANADIAN
							F	FOREIGN

STATION OCCUPIED 0908						
	A	PILOT	D	NAVIGATOR	Y	OTHER
	B	SECOND IN COMMAND	E	REST POSITION		
	C	FLIGHT ENGINEER	F	PASSENGER CABIN		

SPECIAL FUNCTION 0909								
	A	NONE	C	COMPANY EXAMINER	E	TECHNICIAN	Y	OTHER
	B	INSTRUCTOR	D	MOT EXAMINER	F	STUDENT		

PILOT LICENCES 0910						
	A	STUDENT	D	AIRLINE TRANSPORT	V	PRIVATE ROTORCRAFT
	B	PRIVATE	T	GLIDER	W	COMMERCIAL ROTORCRAFT
	C	COMMERCIAL	U	FREE BALLOON	X	SENIOR COMMERCIAL ROTORCRAFT ENDORSEMENT
	S	SENIOR COMMERCIAL	I	NONE	Y	AIRLINE TRANSPORT ROTORCRAFT ENDORSEMENT
	M	OTHER				

TYPE RATING 0911								
	Y	YES	X	NO	LAST CHECK ON TYPE 0912			WEEKS

INSTRUMENT RATING 0913/0914									
	A	AEROPLANE	E	BOTH	1	CLASS I	LAST CHECK	F	FLIGHT
	C	HELICOPTER	Z	UNKNOWN	2	CLASS II	INSTRUMENT RATING 0915/0916 WEEKS	S	SIMULATOR

INSTRUCTOR 0917 RATING						
	Y	YES	X	NO	CLASS- 0918	

CLASS RATINGS (Select up to 2) 0919						
	A	AEROPLANE SE LAND	D	AEROPLANE ME SEA	H	HELICOPTER TYPE
	B	AEROPLANE ME LAND	AC	AEROPLANE SE LAND & SEA	Y	OTHER
	C	AEROPLANE SE SEA	AD	AEROPLANE ME LAND & SEA		

ENDORSEMENTS 0920						
	N	NIGHT	B	BLOCK AIRSPACE	A	AEROBATIC

FLYING TIMES (to nearest hour – if unknown complete with X)

	ALL TYPES	THIS TYPE	DUAL THIS TYPE	THIS U/C CONFIG	SINGLE ENGINE	MULTI ENGINE	ACTUAL INSTRUMENT	SIMULATED INSTRUMENT	NIGHT	ROTORCRAFT
TOTAL HOURS	0921	0923	0925	0927	0929	0931	0933	0935	0937	0939
HRS LAST 90 DAYS	0922	0924	0926	0928	0930	0932	0934	0936	0938	0940

HOURS LAST 30 DAYS 0941	HOURS LAST 3 DAYS 0942	HOURS LAST 24 HOURS 0943	DUTY TIME PRIOR TO OCCURRENCE 0944	REST TIME BEFORE DUTY 0945	HOURS AWAKE SINCE LAST REST PERIOD 0946	LANDINGS ON TYPE LAST 90 DAYS (FIXED WING) 0947	TOTAL INSTRUMENT LAST 30 DAYS 0948

MEDICAL STATUS 0949						
	1	VALID MEDICAL WITH NO WAIVERS/LIMITATIONS	2	VALID MEDICAL WITH WAIVERS/LIMITATIONS	3	NON-VALID MEDICAL

FLYING SCHOOL	ATC LICENCE NUMBER	CODE (NO USE) 0950

PRIME INSTRUCTOR - NAME 0951/0952					
	F	FULL-TIME INSTRUCTOR AT SCHOOL	DUAL LAST 6 MONTHS	DUAL LAST YEAR	
	P	PART-TIME INSTRUCTOR AT SCHOOL			
FLIGHT TEST EXAMINER - NAME & LICENCE 0953/0954	M	MOT	C	COMPANY	
	D	DFTE	0955	0956	

NOTES:

PERSONNEL INFORMATION – COPILOT/DUAL STUDENT

AGE	SEX	SURNAME	INITIALS	LICENCE NUMBER	CREWMEMBER NATIONALITY	
0601	M / F	0603	0604	0605/0606	0608	C CANADIAN / F FOREIGN

STATION OCCUPIED 0607						
	A	PILOT	H	NAVIGATOR	Y	OTHER
	B	SECOND IN COMMAND	E	REST POSITION		
	C	FLIGHT ENGINEER	F	PASSENGER CABIN		

SPECIAL FUNCTION 0608								
	A	NONE	C	COMPANY EXAMINER	E	TECHNICIAN	Y	OTHER
	B	INSTRUCTOR	D	MOT EXAMINER	F	STUDENT		

PILOT LICENCES 0609						
	A	STUDENT	D	AIRLINE TRANSPORT	V	PRIVATE ROTORCRAFT
	B	PRIVATE	T	GLIDER	W	COMMERCIAL ROTORCRAFT
	C	COMMERCIAL	U	FREE BALLOON	X	SENIOR COMMERCIAL ROTORCRAFT ENDORSEMENT
	S	SENIOR COMMERCIAL	I	NONE	Y	AIRLINE TRANSPORT ROTORCRAFT ENDORSEMENT
	H	OTHER				

TYPE RATING 0610								
	Y	YES	X	NO	LAST CHECK ON TYPE 0611			WEEKS

INSTRUMENT RATING 0612/0613									
	A	AEROPLANE	E	BOTH	1	CLASS I	LAST CHECK INSTRUMENT RATING 0614/0615	F	FLIGHT
	C	HELICOPTER	Z	UNKNOWN	2	CLASS II	WEEKS	S	SIMULATOR

INSTRUCTOR RATING 0616					
	Y	YES	X	NO	CLASS- 0617

CLASS RATINGS (Select up to 2) 0618						
	A	AEROPLANE SE LAND	D	AEROPLANE ME SEA	H	HELICOPTER TYPE
	B	AEROPLANE ME LAND	AC	AEROPLANE SE LAND & SEA	Y	OTHER
	C	AEROPLANE SE SEA	BD	AEROPLANE ME LAND & SEA		

ENDORSEMENTS 0619						
	N	NIGHT	B	BLOCK AIRSPACE	A	AEROBATIC

FLYING TIMES (to nearest hour – if unknown complete with X)

	ALL TYPES	THIS TYPE	DUAL THIS TYPE	THIS U/C CONFIG	SINGLE ENGINE	MULTI ENGINE	ACTUAL INSTRUMENT	SIMULATED INSTRUMENT	NIGHT	ROTORCRAFT
TOTAL HOURS	0620	0622	0624	0626	0628	0630	0632	0634	0636	0638
HRS LAST 90 DAYS	0621	0623	0625	0627	0629	0631	0633	0635	0637	0639

HOURS LAST 30 DAYS	HOURS LAST 3 DAYS	HOURS LAST 24 HOURS	DUTY TIME PRIOR TO OCCURRENCE	REST TIME BEFORE DUTY	HOURS AWAKE SINCE LAST REST PERIOD	LANDINGS ON TYPE LAST 90 DAYS (FIXED WING)	TOTAL INSTRUMENT LAST 30 DAYS
0640	0641	0642	0643	0644	0645	0646	0647

MEDICAL STATUS 0648						
	1	VALID MEDICAL WITH NO WAIVERS/LIMITATIONS	2	VALID MEDICAL WITH WAIVERS/LIMITATIONS	3	NON-VALID MEDICAL

FLYING SCHOOL	ATC LICENCE NUMBER	CODE (HQ USE) 0649

PRIME INSTRUCTOR - NAME 0650/0651					DUAL LAST 6 MONTHS	DUAL LAST YEAR
	F	FULL-TIME INSTRUCTOR AT SCHOOL				
	P	PART-TIME INSTRUCTOR AT SCHOOL				
FLIGHT TEST EXAMINER - NAME & LICENCE 0652/0653	M	MOT	C	COMPANY	0654	0655
	D	DFTE				

NOTES:

PERSONNEL – OTHER FLIGHT CREW & AIR TRAFFIC CONTROLLER

CREW IDENTIFIER (1) 0701	A	FLIGHT ENGINEER/ SYSTEMS OPERATOR	B	NAVIGATOR	E	SUPERVISORY ENGINEER	G	SUPERVISORY RADIO OPERATOR
	D	SUPERVISORY PILOT	C	RADIO OPERATOR	F	SUPERVISORY NAVIGATOR	S	PILOT UNDER INSTRUCTION

AGE 0702 YEARS	TOTAL FLYING EXPERIENCE 0703 HOURS	EXPERIENCE ON TYPE 0704 HOURS	
VALIDITY OF LICENCES 0705	A VALID / B NOT VALID	RATINGS PERTINENT TO ACCIDENT FLIGHT 0706	Y YES / X NO
MEDICAL STATUS 0707	1 VALID MEDICAL WITH NO WAIVERS/LIMITATIONS	2 VALID MEDICAL WITH WAIVERS/LIMITATIONS	3 NON-VALID MEDICAL

CREW IDENTIFIER (2) 0708	A	FLIGHT ENGINEER/ SYSTEMS OPERATOR	B	NAVIGATOR	E	SUPERVISORY ENGINEER	G	SUPERVISORY RADIO OPERATOR
	D	SUPERVISORY PILOT	C	RADIO OPERATOR	F	SUPERVISOR NAVIGATOR	S	PILOT UNDER INSTRUCTION

AGE 0709 YEARS	TOTAL FLYING EXPERIENCE 0710 HOURS	EXPERIENCE ON TYPE 0711 HOURS	
VALIDITY OF LICENCES 0712	A VALID / B NOT VALID	RATINGS PERTINENT TO ACCIDENT FLIGHT 0713	Y YES / X NO
MEDICAL STATUS 0714	1 VALID MEDICAL WITH NO WAIVERS/LIMITATIONS	2 VALID MEDICAL WITH WAIVERS/LIMITATIONS	3 NON-VALID MEDICAL

CREW IDENTIFIER (3) 0715	A	FLIGHT ENGINEER/ SYSTEMS OPERATOR	B	NAVIGATOR	E	SUPERVISORY ENGINEER	G	SUPERVISORY RADIO OPERATOR
	D	SUPERVISORY PILOT	C	RADIO OPERATOR	F	SUPERVISORY NAVIGATOR	S	PILOT UNDER INSTRUCTION

AGE 0716 YEARS	TOTAL FLYING EXPERIENCE 0717 HOURS	EXPERIENCE ON TYPE 0718 HOURS	
VALIDITY OF LICENCES 0719	A VALID / B NOT VALID	RATINGS PERTINENT TO ACCIDENT FLIGHT 0720	Y YES / X NO
MEDICAL STATUS 0721	1 VALID MEDICAL WITH NO WAIVERS/LIMITATIONS	2 VALID MEDICAL WITH WAIVERS/LIMITATIONS	3 NON-VALID MEDICAL

AIR TRAFFIC CONTROLLER (associated with flight at time of occurrence)

AGE 0722 YEARS	EXPERIENCE IN POSITION 0723 MO.	DUTY TIME PRIOR TO OCCURRENCE 0724 HR	REST TIME BEFORE DUTY 0725 HR

LICENCE OR QUALIFICATION 0726	A	LICENCED	C	NEITHER LICENCED NOR QUALIFIED	Y	UNIT QUALIFIED
	B	STATE QUALIFIED	D	NO LICENCE REQUIRED		
RATING 0727	A	AERODROME CONTROL W/O RADAR	F	AREA CONTROL W RADAR	G	RADAR-PAR
	B	AERODROME CONTROL W RADAR	C	APPROACH CONTROL W/O RADAR	H	RADAR SRE
	E	AREA CONTROL W/O RADAR	D	APPROACH CONTROL W RADAR	Y	TRAINEE
POSITION OCCUPIED 0728	A	AERODROME CONTROL W/O RADAR	F	AREA CONTROL W RADAR	G	RADAR-PAR
	B	AERODROME CONTROL W RADAR	C	APPROACH CONTROL W/O RADAR	H	RADAR-SRE
	E	AREA CONTROL W/O RADAR	D	APPROACH CONTROL W RADAR		

NOTES:

AIRCRAFT INFORMATION

TOTAL AIRFRAME TIME 0802 Hrs.	TSO 0803 Hrs.	AIRCRAFT WEIGHT 0804	D	AT OR BELOW AUTHORIZED WEIGHT	CENTRE OF GRAVITY 0805	A	EXCEEDED FORWARD LIMIT	C	WITHIN LIMITS
			C	ABOVE AUTHORIZED WEIGHT		B	EXCEEDED AFT LIMIT	D	EXCEEDED LATERAL LIMITS

CALCULATED AUW 0806	C OF G POSITION			OR _____ INCHES	C OF G PERMISSABLE RANGE		
	_____ %MAC			AFT OF DATUM	_____ %MAC TO		AFT OF DATUM
				FORWARD OF DATUM	_____ %MAC		FORWARD OF DATUM

FUEL TYPE 0808	A	80/87	L	AUTOMOBILE GASOLINE	G	JP-3	J	JP-6	Y OTHER
	C	100/130	E	KEROSENE	H	JP-4	K	MIXED FUEL	
	D	115/145	F	JP-1	I	JP-5	Z	UNKNOWN	

POWERPLANT & PROPELLER INFORMATION (Only if an engine or propeller failed)

TSO HRS	NO. 1 ENGINE 0809	NO. 2 ENGINE 0810	NO. 3 ENGINE 0811	NO. 4 ENGINE 0812	NO. 1 PROP. 0813	NO. 2 PROP. 0814	NO. 3 PROP. 0815	NO. 4 PROP. 0816

AIRCRAFT EQUIPPED TO MINIMUM IFR STANDARD 0861	Y	YES			X	NO
AIRCRAFT EQUIPPED FOR PRECISION APPROACHES 0817	A	CAT I	C	CAT III A	E	CAT III C
	B	CAT II	D	CAT III B		
RADAR (AIRBORNE WEATHER) 0818	A	SERVICEABLE NOT IN OPERATION	C	OPERATED SATISFACTORILY	E	NOT INSTALLED
	B	UNSERVICEABLE	D	OPERATED UNSATISFACTORILY	F	INSTALLED OPERATION NOT REPORTED

STALL WARNING PREVENTION SYSTEM 0819	A	WARNING INDICATOR INSTALLED	D	WARNING INDICATOR & STICKPUSHER INSTALLED	WARNING INDICATOR 0820	V	VISUAL	S	STICKSHAKER
	C	STICKPUSHER INSTALLED	B	WARNING INDICATOR OR STICKPUSHER NOT INSTALLED		A	AURAL		

AIRCRAFT EQUIPMENT & SYSTEMS

AVAIL	IN USE	DESCRIPTION		AVAIL	IN USE	DESCRIPTION	
		VHF COMMUNICATION	0821			AUTOPILOT	0838
		HF COMMUNICATION	0822			ANTI-COLLISION LIGHTS	0839
		UHF COMMUNICATION	0823			FLIGHT CREW OXYGEN	0840
		VOR	0824			PASSENGER OXYGEN	0841
		ADF	0825			AUXILIARY POWER	0842
		TACAN	0826			RADAR ALTIMETER	0843
		DME	0827			GROUND PROXIMITY WARNING	0844
		ILS COMPLETE SYSTEM	0828			ALTITUDE ALERTING	0845
		ILS LOCALIZER ONLY	0829			COLLISION AVOIDANCE	0846
		ILS GLIDE PATH ONLY	0830			AREA NAVIGATION	0847
		TRANSPONDER	0831			VLF NAVIGATION	0848
		TRANSPONDER (MODE C)	0832			MLS	0849
		ENGINE ANTI-ICE/DE-ICE	0833			HEAD-UP DISPLAY	0850
		PROPELLER DE-ICE	0834			INERTIAL NAVIGATION	0851
		WINDSHIELD ANTI-ICE/DE-ICE	0835			INTEGRATED FLIGHT DATA	0852
		AIRFRAME ANTI-ICE/DE-ICE	0836			TURBULENCE DETECTION	0853
		DUAL CONTROLS	0837			ICE DETECTION	0862

AIRCRAFT CONFIGURATION AT IMPACT

LANDING GEAR 0864	F	FIXED	U	UP	T	TRANSIT	D	DOWN	AMPHIBIOUS FLOATS – WHEELS SKI-WHEEL 0865		U	UP	D	DOWN
FLAPS 0866	N	NONE			U	UP			P	PARTIAL	D	DOWN		
POWER 0867	N	NONE	P	PARTIAL	F	FULL			R	REVERSE	A	ASSYMETRIC		
MIXTURE 0868	R	RICH	L	LEAN	A	AUTO			C	IDLE CUT-OFF				
CARB HEAT 0869	H	HOT	C	COLD	P	PARTIAL			X	NOT INSTALLED				
INDUCTION HEAT 0870	H	HOT	C	COLD	P	PARTIAL			X	NOT INSTALLED				

AIRCRAFT & SYSTEM MALFUNCTIONS OR FAILURES

LINE	SYSTEM	SYSTEM/COMPONENT	SUB-SYSTEM/SUB-COMPONENT	PART
1				
2				
3				
4				
5				
6				

DETAILS

1

2

3

4

5

6

METEOROLOGICAL INFORMATION

WEATHER BRIEFING 1001	T	BRIEFING AVAILABLE & PROVIDED		H	BRIEFING FACILITIES NOT USED
	U	BRIEFING NOT AVAILABLE		Z	NOT REPORTED
BRIEFING AGENCY 1002	A	NONE	D	COMPANY FACILITY	G	OTHER OBSERVER
	B	ACCREDITED FORECASTER	E	OTHER PILOT	Y	OTHER
	C	ACCREDITED BRIEFER	F	SELF BRIEFING		
WEATHER VS FORECAST 1003	A	SUBSTANTIALLY CORRECT		E	CONSIDERABLY WORSE THAN FORECAST	
	C	CONSIDERABLY BETTER THAN FORECAST				

WEATHER CONDITIONS AT SITE OF OCCURRENCE

GENERAL WEATHER IN AREA OF OCCURRENCE	A	VMC	C	BELOW MINIMA (Landing/Takeoff Only)
	B	IMC	Z	UNKNOWN

WIND DIRECTION 1004 °M	RELATIVE BEARING OF WIND TO TRACK OF AIRCRAFT (A, B, C, D, E, F, G, H) 1006	CLOUD BASE HEIGHT 1007	U UNLIMITED	TEMPERATURE 1010 °C
WIND SPEED 1005 Knots	I CALM / J LIGHT & VARIABLE	VISIBILITY 1008	DENSITY ALTITUDE 1011 Ft	DEWPOINT °C
		RVR 1009	QNH (ALTIMETER SETTING) 1012	DIFFERENCE BETWEEN DEWPOINT AND TEMPERATURE 1014 °C

SKY CONDITION 1015	A	CLEAR	E	BROKEN/LOWER SCATTERED	I	OBSCURED
	B	SCATTERED ABOVE 1000'	G	OVERCAST/LOWER SCATTERED	H	PARTIALLY OBSCURED
	C	SCATTERED BELOW 1000'	F	OVERCAST		
	D	BROKEN				
RESTRICTING PHENOMENA 1016	A	DUST	F	SMOKE	K	PRECIPITATION
	B	FOG (incl. ice crystal fog)	G	BLOWING DUST	L	CLOUDS
	C	SHALLOW FOG	H	SANDSTORM	D	HAZE
	E	FREEZING FOG	I	BLOWING SNOW	Y	OTHER
TYPE OF PRECIPITATION (Select up to 2) 1017	C	DRIZZLE	F	SNOW	I	THUNDERSHOWERS
	D	RAIN	G	SNOW GRAINS/ICE PELLETS	Y	OTHER
	E	RAIN SHOWERS	H	SNOW SHOWERS		
	A	HAIL	J	FREEZING DRIZZLE		
	B	SLEET	K	FREEZING RAIN		
SIGNIFICANT WEATHER (Select up to 3) 1018	A	TURBULENCE IN CLOUD	H	VARIABLE CLOUD BASE	C	TORNADO
	B	CLEAR AIR TURBULENCE	M	LIGHT PRECIPITATION	D	HURRICANE, TYPHOON
	G	SEVERE LINE SQUALL	L	HEAVY PRECIPITATION	E	MOUNTAIN WAVE
	J	WIND VARIABLE	R	THUNDERSTORM	S	NOT SIGNIFICANT
	I	WIND GUSTY	O	SEVERE ICING	T	INVERSION
	K	WIND GUSTY & VARIABLE	N	TEMPERATURE BELOW 0°C	Y	OTHER

CONDITIONS AT POINT OF FIRST IRREGULARITY OF FLIGHT (If applicable)

AIRCRAFT ALTITUDE ASL 1019	TEMPERATURE 1023 °C	RESTRICTING PHENOMENA (enter codes from 1016) 1026	SIGNIFICANT WEATHER (enter codes from 1018) 1027		
GENERAL TERRAIN ELEV. ASL	DEWPOINT °C	PRECIPITATION (enter codes from 1017) 1028	DEGREE OF TURBULENCE 1029	L	LIGHT
AIRCRAFT HEIGHT AGL 1021	DIFFERENCE BETWEEN DEWPOINT & TEMPERATURE 1024 °C			M	MODERATE
				S	SEVERE

NOTES:

GROUND AIDS

AVAIL	IN USE	DESCRIPTION		AVAIL	IN USE	DESCRIPTION	
		PAR	1101			WIND DIRECTION INDICATORS	1113
		SURVEILLANCE RADAR	1102			LANDING DIRECTION INDICATOR	1114
		SECONDARY SURVEILLANCE RADAR	1103			RUNWAY EDGE, THRESHOLD & END LIGHTS	1115
		ILS - COMPLETE SYSTEM	1104			STOPWAY LIGHTING	1116
		ILS - GLIDE PATH ONLY	1105			RUNWAY CENTRE LINE LIGHTS	1117
		ILS - LOCALIZER ONLY	1106			RUNWAY TOUCHDOWN ZONE LIGHTS	1118
		VORTAC	1107			TAXIWAY EDGE LIGHTS	1119
		VOR/TVOR	1108			TAXIWAY CENTRE LINE LIGHTS	1120
		NDB	1109			STOP BARS	1121
		DME	1110			VLF GROUND STATION	1122
		MICROWAVE LANDING SYSTEM	1111			VHF/UHF DF	1123
		APPROACH LIGHTS	1112			VASI	1124

TYPE OF APPROACH LIGHTS	1	SIMPLE (SINGLE SOURCE)	TYPE OF VASI	2	VASIS
	2	SIMPLE (BARRETTE)		1	3 BAR VASIS
	3	PRECISION - CAT I CALVERT		4	3 BAR AVASIS
	4	PRECISION - CAT I BARRETTE		5	AVASIS
	5	PRECISION - CAT II		3	T - VASIS
	6	PRECISION - CAT III		6	AT - VASIS
1125	Y	OTHER	1126	Y	OTHER

RUNWAY USED	A	NON-INSTRUMENT	C	CAT I	E	CAT III A	G	CAT III C
1127	B	INSTRUMENT	D	CAT II	F	CAT III B		

COMMUNICATIONS

1128 TWO WAY COMMUNICATION	A	ESTABLISHED & SATISFACTORY	B	ESTABLISHED & NOT SATISFACTORY	X	NOT ESTABLISHED
GROUND STATION LAST IN CONTACT	A	AIRPORT CONTROL TOWER	D	FLIGHT INFORMATION CENTRE	G	FLYING CLUB/UNICOM
	B	APPROACH CONTROL	E	FLIGHT INFORMATION SERVICE	Y	OTHER
1129	C	AREA CONTROL CENTRE	F	OPERATOR GROUND STATION		
1130 RECORD OF ATS COMMUNICATION	A	AVAILABLE	B	PARTIALLY AVAILABLE	C	NOT AVAILABLE

RECORD OF RT COMMUNICATION (Select up to 2)	A	AVAILABLE AND FUNCTIONING	D	TRANSCRIPTS MADE
	B	AVAILABLE AND NOT FUNCTIONING	F	TRANSCRIPTS NOT MADE
1131	C	AVAILABLE AND PARTIALLY FUNCTIONING	E	TRANSCRIPTS PARTIALLY MADE

NOTES:

WRECKAGE & IMPACT INFORMATION

1201 WRECKAGE EXAMINED | Y YES | X NO

TYPE OF TERRAIN 1202				
	A	MOUNTAINOUS	C	ROLLING
	B	HILLY	D	LEVEL FLAT

SURFACE CONDITION GENERAL 1203						
	D	HARD	H	TREE COVERED	K	WATER
	F	ROCKY	I	BUILT-UP (CITY-DENSE)	N	SWAMP
	G	SANDY	J	BUILT-UP (SUBURBAN-COUNTRY-SPARSE)	V	OTHER

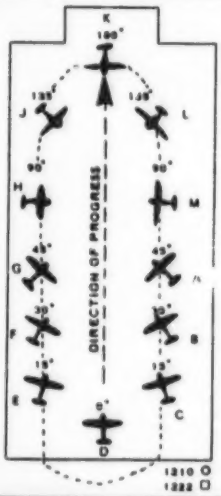
SURFACE CONDITION SPECIFIC 1204						
	O	PAVED	S	MUD, WET SOIL	1	SNOW
	P	LOOSE	T	HIGH WAVES	2	ICE
	Q	COMPACT	U	SWELLS	4	MODERATE WAVES
	J	CULTIVATED	V	CALM GLASSY WATER	V	OTHER
	R	LOW VEGETATION GRASS	E	FROZEN GROUND		

ELEVATION OF FIRST POINT OF IMPACT 1205	LENGTH OF WRECKAGE TRAIL 1206	IMPACT ANGLE (RELATIVE TO TERRAIN/OBJECT) 1207
_____ Feet	_____ Feet	_____ Degrees
_____ Metres	_____ Metres	

- CIRCLE THE SILHOUETTES WHICH MOST CLOSELY DESCRIBE ANGLE OF GROUND CONTACT
- DRAW A SQUARE AROUND SILHOUETTES TO DESCRIBE ATTITUDE OF AIRCRAFT AT REST

REAR ELEVATION 1208 ○ 1220 □

STARBOARD ELEVATION 1209 ○ 1221 □



1210 ○ 1222 □

AERODROME PROXIMITY 1212							DIRECTION FROM AERODROME TO SCENE OF OCCURRENCE 1213
	A	ON AERODROME	F	WITHIN .4 KM (¼ nm)	K	WITHIN 4.8 Km (3 nm)	
	B	ON SEAPLANE BASE	G	WITHIN .8 Km (½ nm)	L	WITHIN 6.4 Km (4 nm)	
	C	ON HELIPORT	H	WITHIN 1.2 Km (¾ nm)	M	WITHIN 8 Km (5 nm)	
	D	ON/BARGE/SHIP/PLATFORM	I	WITHIN 1.6 Km (1 nm)	N	BEYOND 8 Km	
	E	IN CIRCUIT	J	WITHIN 3.2 Km (2 nm)			

COMPLETE P13 IF AIRCRAFT WAS OPERATING INTO OR OUT OF AN AERODROME WITHIN 8 KM

WATER AERODROME OR OTHER AREA USED FOR TAKEOFF/LANDING?

LENGTH 1214 ▶ ft METRES | WIDTH 1215 ▶ ft METRES

WATER CONDITIONS (Select up to 2) 1216						
	A	GLASSY	C	LIGHT SWELL	E	HEAVY SWELLS
	B	WAVES < 0.3 metres	D	WAVES .3m to 1m.	F	WAVES > 1 metre

WATER SURFACE HAZARDS (Select up to 2) 1217						
	A	SAND BAR	C	SUBMERGED OBSTRUCTION	E	BOATS
	B	SHOAL	D	FLOATING OBJECTS	Y	OTHER

HAZARDS BORDERING AREA (Select up to 2) 1218						
	A	HIGH GROUND	D	FENCE	HEIGHT ABOVE SURFACE 1219	
	B	WIRES/POLES	E	BUILDINGS		
	C	TREES	Y	OTHER		

NOTES:

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AERODROME INFORMATION

AERODROME NAME (1300)	ELEVATION ASL (1301)	TYPE (1302)				IF LAND – CIRCLE RUNWAY CLASS
			L	LAND	H	HELIPORT
			W	WATER		A B C D E

AERODROME CATEGORY (1303)								AERODROME CONTROL (1304)		
	A	MUNICIPAL (COMMERCIAL)	D	FEDERAL	G	PREPARED LANDING AREA			A	ATC OPERATING
	B	MILITARY	E	PRIVATE STRIP	Y	OTHER			B	ATC NOT OPERATING
	C	JOINT MILITARY/CIVIL	F	LOCAL AERODROME					E	NO ATC SERVICE

RUNWAY IDENTIFICATION (1305)	AVAILABLE LENGTH (1306)	RUNWAY WIDTH (1307)	TAXIWAY WIDTH (1308)

POINT OF FIRST IMPACT OR TOUCHDOWN		POINT WHERE AIRCRAFT CAME TO REST		POINT WHERE AIRCRAFT LEFT RUNWAY			
DISTANCE FROM THRESHOLD (1309)	BEARING FROM RUNWAY HDG. (1311)	DISTANCE FROM THRESHOLD (1313)	BEARING FROM RUNWAY HDG. (1315)	DIRECTION (1317)			DISTANCE ALONG RUNWAY (1319)
				L	LEFT SIDE		
				R	RIGHT SIDE		
				E	END		

OVERRUN/ UNDERSHOOT AREA (1320)								
	A	UNOBSTRUCTED	C	SOFT SURFACE	G	COVERED BY WATER	E	SUITABLE
	B	OBSTRUCTED	D	ROUGH, UNEVEN SFCE			F	NOT SUITABLE

APPROACH AREA AND RUNWAY HAZARDS (1321)						
	A	UNMARKED OBSTRUCTION	B	SOFT SHOULDERS	D	SNOW BANK/WINDROW
	E	MARKED OBSTRUCTION	C	EXPOSED LIP AT THRESHOLD	Y	OTHER

COMPLETE AREA BELOW IF AIRCRAFT WAS ON THE RUNWAY DURING THE OCCURRENCE

RUNWAY SURFACE TYPE (1322)						
	A	MACADAM (ROLLED GRAVEL)	C	GRASS	F	GRAVEL
	B	CONCRETE	D	DIRT	G	CORAL
	I	ASPHALT	E	SHELL	Y	OTHER

RUNWAY SURFACE CHARACTERISTICS (1323)						
	A	GROOVED	C	SMOOTH TEXTURE	Y	OTHER
	B	POROUS	D	ROUGH TEXTURE		

RUNWAY SURFACE STATUS (1324)						
	K	DRY	F	SNOW-COMPACTED	E	VEGETATION > 15 cm
	A	WET	D	SNOW-SLUSH	J	CLEAR
	L	WATER COVERED	C	ICE	Y	OTHER
	M	SNOW-DRY	F	ROUGH, UNEVEN		
	N	SNOW-WET	G	RUBBER DEPOSITS		
	I	SNOW-CRUSTED	O	SOFT		

RUNWAY PROFILE (1325)		AVERAGE SLOPE % (1326)		RUNWAY FRICTION MEASURING EQUIPMENT		EQUIPMENT USED (1328)				BRAKING ACTION (1330)	
L	LEVEL					J	JBD	T	TAPLEY METER	A	POOR
U	UP					M	MU-METER	F	MESS-FIX	B	POOR TO MEDIUM
D	DOWN			A	AVAILABLE-USED	O	DBV	E	ESTIMATED	C	MEDIUM
A	DOWN-UP	DN	UP	B	AVAILABLE-NOT USED	S	SKIDOMETER	Y	OTHER	D	MEDIUM TO GOOD
B	UP-DOWN	UP	DN	C	NOT AVAILABLE	R	SAAB FRICTION METER			E	GOOD

NOTES:

SURVIVAL DATA

SURVIVABILITY 1401	A	SURVIVABLE	C	NON SURVIVABLE	POST CRASH ESCAPE 1402	A	UNHAMPERED	C	NOT APPLICABLE
	B	PARTIALLY SURVIVABLE	D	AIRCRAFT MISSING		B	WITH DIFFICULTY	D	UNDETERMINED

IMPACT DAMAGE-AIRCRAFT WITHOUT PASSENGER CABIN 1403	A	EXTREME	C	MODERATE	E	NONE	
	B	SEVERE	D	MINOR			

IMPACT DAMAGE-AIRCRAFT WITH PASSENGER CABIN	1404 COCKPIT		1405 FORWARD CABIN		1406 CENTRE CABIN		1407 AFT CABIN	
	A	EXTREME	A	EXTREME	A	EXTREME	A	EXTREME
	B	SEVERE	B	SEVERE	B	SEVERE	B	SEVERE
	C	MODERATE	C	MODERATE	C	MODERATE	C	MODERATE
	D	MINOR	D	MINOR	D	MINOR	D	MINOR
	E	NONE	E	NONE	E	NONE	E	NONE

SEATING CONFIGURATION 1408	A	FORWARD FACING	C	COMBINATION FORWARD & REAR			
	B	REAR FACING	Y	OTHER			
SEAT BELT SIGN 1409	C	NOT INSTALLED	A	ON	B	OFF	

SHOULDER HARNESS	1410 PILOT				1411 CO-PILOT			
	A	INSTALLED/USED/HELD	C	INSTALLED/NOT USED	A	INSTALLED/USED/HELD	C	INSTALLED/NOT USED
	B	INSTALLED/USED/FAILED	D	NOT INSTALLED	B	INSTALLED/USED/FAILED	D	NOT INSTALLED

EVACUATION ASSISTANCE BY GROUND RESCUE GROUPS 1412	A	RENDERED EFFECTIVELY	C	AVAILABLE-UNABLE TO RENDER ASSISTANCE		
	B	ARRIVED TOO LATE	D	NOT AVAILABLE	E	NOT NECESSARY

NUMBER OF SEATS FAILED 1413	NUMBER OF SEAT BELTS FAILED 1414	FATALITIES FROM BURNS 1415	FATALITIES FROM TOXIC FUMES 1416

MEANS OR METHOD OF EXIT (Select up to 4) 1417							
	A	MAIN DOOR FORWARD	E	AUXILIARY DOOR AFT	I	COCKPIT WINDOW	
	B	MAIN DOOR AFT	F	AUXILIARY DOOR OTHER	J	OTHER WINDOW	
	M	OPENING CUT BY RESCUERS	G	MAIN & AUXILIARY DOORS	K	BREAK IN FUSELAGE	
	D	AUXILIARY DOORS FORWARD	H	EMERGENCY WINDOW EXITS	L	THROWN CLEAR	

EVACUATION TIME 1418								NUMBER OF OCCUPANTS EVACUATED 1419	NUMBER OF OCCUPANTS NOT EVACUATED 1420
	A	0-30 SEC	D	91-120 SEC	G	4-5 MIN			
	B	31-60 SEC	E	2-3 MIN	H	OVER 5 MIN			
	C	61-90 SEC	F	3-4 MIN	I	UNKNOWN			

CHUTE/SLIDE 1421								
	A	AVAILABLE USED EFFECTIVELY	B	AVAILABLE-USED-MALFUNCTIONED	C	AVAILABLE-NOT USED	D	NOT AVAILABLE

1422 ROPE		1423 LADDER		1424 EMERGENCY EXITS		1425 EMERGENCY LIGHTS	
A	AVAILABLE-USED	A	AVAILABLE-USED	A	USED-FUNCTIONED NORMALLY	A	ENERGIZED PROPERLY
B	AVAILABLE-NOT USED	B	AVAILABLE-NOT USED	B	NOT USED-FUNCTIONED NORMALLY	B	DID NOT ENERGIZE
C	NOT AVAILABLE	C	NOT AVAILABLE	C	WOULD NOT OPEN	C	NOT AVAILABLE

DITCHING-WATER CONDITIONS & AIRCRAFT INTEGRITY 1426		OPEN SEA		CALM SURFACE		AIRCRAFT BROKE UP
		SHELTERED AREA		ROUGH SURFACE		AIRCRAFT REMAINED INTACT

DITCHING-AIRCRAFT SANK/STAYED AFLOAT 1427	A	INSUFFICIENT TIME FOR EVACUATION
	B	SUFFICIENT TIME FOR PARTIAL EVACUATION
	C	SUFFICIENT TIME FOR COMPLETE EVACUATION
	D	STAYED AFLOAT-EXTENDED PERIOD AFTER EVACUATION

NOTES:

FIRE DATA

FIRE STARTED 1901/1902	A	IN FLIGHT	C	> 1 MIN AFTER IMPACT	E	UNDETERMINED	
	B	< 1 MIN AFTER IMPACT	D	DURING REFUELLING		ON OR AFTER IMPACT TIME UNDETERMINED	

INDICATIONS OF FIRE 1903	A	FIRE WARNING SYSTEM	C	SIGHT	E	EXPLOSION	Y	OTHER	
	B	OTHER INSTRUMENTS	D	SMELL	F	EXTERNAL COMMUNICATION			

FIRE DAMAGE 1904	D	NONE	C	0-25%	B	26-50%	B	51-75%	A	76-100%

AIRCRAFT FIRE WARNING SYSTEM OPERATION 1905	A	FUNCTIONED PROPERLY	C	NOT INSTALLED
	B	FAILED TO OPERATE	E	UNKNOWN

INITIAL LOCATION OF FIRE 1906	GENERAL	A	POWERPLANT	D	COCKPIT	G	TAIL UNIT	J	SYSTEM COMPARTMENT
		B	BAGGAGE COMPARTMENT	E	WHEEL NACELLE	H	TOILET	Y	OTHER
		C	PASSENGER CABIN	F	WING	I	APU		
	SPECIFIC 1907	A	OXYGEN SYSTEM	D	JUNCTION BOX	G	TRANSMISSION SECTION	L	TAIL PIPE
		B	INSTRUMENT PANEL	E	HEATER COMPARTMENT	H	JATO	M	TIRES
		C	BATTERY COMPARTMENT	F	AVIONICS SECTION	K	WHEELBRAKE	Y	OTHER

COMBUSTIBLE MATERIAL (Select up to 3) 1908	A	MAIN FUEL	F	ELECTRICAL INSULATION	M	CARGO	
	B	AUXILIARY FUEL	G	ACOUSTICAL MATERIALS	N	EXTERNAL MATERIAL	
	C	HYDRAULIC FLUID	H	METAL	P	UNDETERMINED	
	D	ENGINE OIL	K	EXPLOSIVES	Y	OTHER	
	E	TRANSMISSION OIL	L	UPHOLSTERY			

IGNITION SOURCE (Select up to 3) 1909	A	EXHAUST FLAMES	E	AIRCRAFT SUBSYSTEM	K	SHORT CIRCUIT
	B	SPARKS (FRICTION, SKIDDING)	F	AIRCRAFT OCCUPANT (eg LIGHTED CIGAR)	L	LIGHTNING
	C	ELECTRICAL SPARKS	G	CARGO	M	STATIC ELECTRICITY
	D	HOT SURFACES (EXHAUST DUCTS)	H	EXPLOSIVES	Y	OTHER

EXTINGUISHER SYSTEM (MANUALLY OPERATED) 1910	A	ACTIVATED - EFFECTIVE (WITHIN SELECTED AREA)	C	ACTIVATED - INEFFECTIVE (WITHIN SELECTED AREA)	E	NOT EQUIPPED
	B	ACTIVATED - FAILED TO OPERATE	D	NOT ACTIVATED		
CRASH FIRE 1911 INERTING SYSTEM	A	AVAILABLE - OPERATED EFFECTIVELY	B	AVAILABLE - INEFFECTIVE	C	NOT EQUIPPED

EXTINGUISHER SYSTEM AGENTS USED	FIXED EQP'T 1912	A	CO_2 CARBON DIOXIDE	C	DB DIBROMODI - FLUOROMETHANE	E	MB METHYL BROMIDE
		B	CB CHLOROBROMETHANE	D	BT BROMO - TRIFLUOROMETHANE	Y	OTHER
	PORTABLE EQP'T 1913	A	CO_2 CARBON DIOXIDE	C	WATER SOLUTIONS	E	CARBON TETRACHLORIDE
		B	CB CHLOROBROMETHANE	D	DRY CHEMICAL	Y	OTHER

FUEL ON BOARD AT OCCURRENCE	1918 Kg	OIL ON BOARD AT OCCURRENCE	1919 litres

SPILLAGE DATA 1920 (Select up to 3)	A	RUPTURED FUEL LINES	C	RUPTURED HYDRAULIC LINES	E	ENGINE OIL SPILLED
	B	RUPTURED FUEL CELLS	D	TRANSMISSION OIL SPILLED	Y	OTHER

AIRCRAFT EQUIPPED WITH CRASH RESISTANT	FUEL CELLS 1921		YES		NO	FUEL LINES 1922		YES		NO

FIRE DIMENSIONS - TO CLEAR FIRE, OCCUPANTS HAD TO MOVE 1923	_____ METRES	DISTANCE TO NEAREST AVAILABLE FIREFIGHTING EQUIPMENT 1924	_____ Km

CONTROL OF FIRE		EFFECTIVELY CONTROLLED		NOT EFFECTIVELY CONTROLLED

ELAPSED TIME – OCCURRENCE TO ALERTING	MIN.	ELAPSED TIME – OCCURRENCE TO ARRIVAL ON SCENE	MIN.	ELAPSED TIME – OCCURRENCE TO CONTROL OF FIRE	MIN.

EVIDENCE OF TOXIC PRODUCTS 1925	Y	YES	X	NO		
TOXIC GASES PRODUCED (Select up to 4) 1926	A	HCl HYDROGEN CHLORIDE	E	NO_2 NITROGEN DIOXIDE	R	PHOSGENE
	B	SO_2 SULPHUR DIOXIDE	F	CYANIDES	L	HF HYDROGEN FLUORIDE
	C	BENZENE	G	Cl_2 CHLORINE	Y	OTHER
	D	UNSATURATED HYDROCARBONS	H	ARSINE		

SEARCH 1601

AIRCRAFT FOUND BY 1602	A	SAR ORGANISATION	D	RCMP	G	MOT
	B	PRIVATE AGENCY	E	PROVINCIAL POLICE	H	NOT FOUND
	C	COMMERCIAL AGENCY	F	MUNICIPAL POLICE	Y	OTHER
SEARCH BY 1603	A	GROUND	C	BOAT	E	GROUND/AIR
	B	AIR	D	AIR/BOAT	F	ALL MODES
LOCATING METHOD 1604	A	L/F RADIO	D	VISUAL-MIRROR	G	VISUAL-PYROTECHNICS
	B	ELT	E	VISUAL-SMOKE/FIRE	H	VISUAL-OTHER
	C	VHF/UHF HOMING	F	VISUAL/WRECKAGE	Y	OTHER

ELAPSED TIME — ACCIDENT TO NOTIFICATION 1605 _____ Days _____ hours — ACCIDENT TO SEARCH SUCCESS 1606 _____ Days _____ hours

ELT 1607

ELT 1608	A	INSTALLED-FIXED-USED-EFFECTIVE IN RESCUE
	B	INSTALLED-FIXED-USED-INEFFECTIVE/FAILED TO FUNCTION
	D	PORTABLE-CARRIED-USED-EFFECTIVE IN RESCUE
	E	PORTABLE-CARRIED-USED-INEFFECTIVE/FAILED TO FUNCTION
	C	NOT INSTALLED/NOT CARRIED

ELT ACTIVATION 1609	M	MANUAL	A	AUTOMATIC	X	DID NOT ACTIVATE		
ELT LOCATION 1610	F	COCKPIT	C	CABIN	R	REAR OF AIRCRAFT	Y	OTHER
ELT TYPE 1611	A	A-AUTOMATIC EJECTABLE	F	F-FIXED	P	P-PERSONAL	W	W-WATER ACTIVATED

ELT NOT EFFECTIVE REASON	A	INSUFFICIENT G TO ACTIVATE	E	IMPROPER INSTALLATION	K	ANTENNA BROKEN OFF
	B	PHYSICAL DAMAGE IN CRASH	F	IMPROPER MAINTENANCE	L	NOT SWITCHED ON
	C	SHIELDING BY WRECKAGE	G	SWITCHED OFF BY CRASH	M	FIRE DAMAGE
	D	SHIELDING BY TERRAIN	H	SHORTED	N	WATER SUBMERSION

ELT MANUFACTURER 1613 ▶ — ELT MODEL ▶

FLIGHT RECORDERS 1615

FDR INSTALLATION 1616	A	DIGITAL FDR	E	DIGITAL & ANALOGUE FDR'S	NUMBER OF RECORDED PARAMETERS 1617 ▶	
	C	ANALOGUE FDR	J	MAINTENANCE RECORDERS		

FDR RECOVERY 1618	A	RECOVERED INTACT	C	RECOVERED-DESTROYED BY FIRE		
	B	RECOVERED-DESTROYED BY IMPACT	D	RECOVERED-PARTIALLY DESTROYED		
	X	NOT RECOVERED	K	RECOVERED-DAMAGED BY IMPACT & FIRE		
FDR LOCATION 1619	A	TAIL UNIT OR REAR OF FUSELAGE	B	MID-FUSELAGE	C	FRONT-FUSELAGE
	Y	OTHER				
FDR RECORDING MEDIUM 1620	A	ENGRAVED FOIL	C	PLASTIC TAPE METAL COATED	E	WIRE
	B	PHOTOGRAPHIC PAPER	D	METAL TAPE	Y	OTHER
FDR OPERATION 1621	A	FUNCTIONED PROPERLY	E	MEDIUM RAN OUT	G	INFORMATION NOT RECOVERABLE
	B	DID NOT FUNCTION PROPERLY	F	COMPLETE INFORMATION RECOVERED		
	K	NOT SWITCHED ON	J	INFORMATION NOT COMPLETELY RECOVERED		
CVR INSTALLATION 1622	A	CVR REQUIRED-INSTALLED	C	CVR NOT REQUIRED-NOT INSTALLED	NUMBER OF CVR CHANNELS 1623	
	B	CVR REQUIRED-NOT INSTALLED	D	CVR NOT REQUIRED BUT INSTALLED		
CVR RECOVERY 1624	A	RECOVERED INTACT	C	RECOVERED-DESTROYED BY FIRE		
	B	RECOVERED-DESTROYED BY IMPACT	D	RECOVERED-PARTIALLY DESTROYED		
	X	NOT RECOVERED				
CVR LOCATION 1625	A	TAIL UNIT OR REAR OF FUSELAGE	B	MID-FUSELAGE	C	FRONT-FUSELAGE
	Y	OTHER				
CVR RECORDING MEDIUM 1626	A	PLASTIC TAPE, METAL COVERED	C	WIRE		
	B	METAL TAPE	Y	OTHER		
CVR OPERATION 1627	A	FUNCTIONED PROPERLY	D	ERASED		
	B	DID NOT FUNCTION PROPERLY	E	COMPLETE INFORMATION RECOVERED	G	INFORMATION NOT RECOVERABLE
	C	NOT SWITCHED ON	F	INFORMATION NOT COMPLETELY RECOVERED		

NOTES:

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AERIAL APPLICATION

KIND OF OPERATION 1701	A	DUSTING CROPS	F	FERTILIZING (LIQUID)	K	SPRAYING TOWNS	Q	CHASING BIRDS
	B	DUSTING-OTHER	G	DEFOLIATION (DUST)	L	AGITATING TREES	R	TEST
	C	SEEDING CROPS	H	DEFOLIATION (LIQUID)	M	ANTI-FROST OPS	S	FERRY
	D	SEEDING FORESTS	I	SPRAYING CROPS	N	KNOCKING FRUIT OFF TREES	T	PRACTICE
	E	FERTILIZING (DUST)	J	SPRAYING FORESTS	P	SURVEYING AREA	W	FIRE CONTROL
	V	OTHER – SPECIFY						
KIND OF CROP/ TERRAIN 1702	A	BEANS	G	ORCHARDS	M	PASTURE	S	SPINACH
	B	CLOVER	H	GRAPES	N	PEAS	T	STRAWBERRIES
	C	CORN	I	GRAIN FIELDS	P	POTATOES	U	TOBACCO
	E	FLAX	J	LETTUCE	Q	RICE	V	TOMATOES
	F	FOREST-TREES	L	MOSQUITO CONTROL	R	SAGE	Y	OTHER-

CHEMICAL USED 1703	A	DRY-TOXIC	B	DRY-NON TOXIC	C	LIQUID-TOXIC	D	LIQUID-NONTOXIC
TOXIC EFFECT ON PILOT 1704	A	NOT AFFECTED	B	AFFECTED IN FLIGHT	C	AFFECTED ON GROUND BEFORE FLIGHT		
PILOT'S DURATION OF EXPOSURE 1705	A	LESS THAN 15 MIN.	D	LESS THAN 2 HOURS	G	LESS THAN 5 HOURS		
	B	LESS THAN 30 MIN.	E	LESS THAN 3 HOURS	H	OVER 5 HOURS		
	C	LESS THAN 1 HOUR	F	LESS THAN 4 HOURS				
TOXIC ANTIDOTES 1706	A	AVAILABLE-USED	B	AVAILABLE-NOT USED	C	NOT AVAILABLE		

SEAT BELT 1707	A	NOT FASTENED	B	FASTENED PROPERLY	C	FASTENED LOOSELY	D	FAILED
RESPIRATION EQUIPMENT 1708	A	AVAILABLE-USED	B	AVAILABLE-NOT USED	C	NOT AVAILABLE		
CRASH HELMET 1709	A	AVAILABLE-USED	B	AVAILABLE-NOT USED	C	NOT AVAILABLE		

SPECIAL CLOTHING 1710		1711 GLOVES		1712 GOGGLES		1713 COCKPIT CRASH PAD		1714 CRASH PAD	
A	USED	A	USED	A	USED	A	INSTALLED	A	INSTALLED
B	NOT USED	B	NOT USED	B	NOT USED	B	NOT INSTALLED	B	NOT INSTALLED

TANK/HOPPER LOCATION 1715	A	FORWARD OF PILOT	C	WINGS	E	SIDES	Y	OTHER
	B	AFT OF PILOT	D	BELLY	F	SLING LOADED		

OBSTRUCTIONS (Select up to 3) 1716	A	TREES	C	FENCES	E	ELECTRONIC TOWERS	Y	OTHER
	B	WIRES POLES	D	BUILDINGS	F	NONE		
TERRAIN BEING TREATED 1717	A	LEVEL, FLAT	C	HILLY	E	SWAMPY/WATER		
	B	ROLLING	D	MOUNTAINOUS	F	DENSE WITH TREES		

1718 SWATH RUN HOW FLOWN	A	CROSSWIND	B	UPWIND	C	DOWNWIND	D	WIND CALM
PROCEDURE TURNAROUND 1719	A	ENTRY TO PROCEDURE TURN			C	SECOND 1/3 OF TURN		
	B	FIRST 1/3 OF TURN			D	LAST 1/3 OF TURN		

PILOT TIME - CROP CONTROL	ELEVATION - AREA BEING TREATED	CHEMICALS USED
1720	1721	1722

NOTES:

INVESTIGATION

INVESTIGATED BY	NUMBER OF INVESTIGATORS		ASSISTANCE FROM DNHW	ASSISTANCE FROM NO LAB	INVESTIGATION BY CORRESPONDENCE
	CAI	TI	2103	2104	2105
	2101	2102	YES	YES	PARTIALLY
			NO	NO	NO
	OTHER ASSISTANCE			2106	YES

PAGES SUBMITTED															
	1	2	3	4	5	6	7	8	9	10	11	C1	C2	C3	C4
	12	13	14	15	16	17	18						M1	M2	M3

APPENDED DOCUMENTS							
INTERVIEWS 2107	A	FLIGHT CREW	E	MAINTENANCE PERSONNEL	K	PERSONAL PHYSICIAN	
	B	EYEWITNESS	F	SPOUSE	L	MANAGEMENT	
	C	INSTRUCTOR/CHECK PILOT	G	PASSENGERS			
	D	CABIN CREW	H	DISPATCH			
REPORTS 2108	A	MATERIALS LAB	D	MEDICAL	G	CORONER	
	B	TECHNICAL	E	DCIEM	H	POLICE	
	C	DATA RECORDER	F	PATHOLOGIST	K	CRIME LAB	SAR
OPERNL DATA 2109	A	PERFORMANCE	D	ATS TAPE TRANSCRIPTION	G	CASUALTY LIST	
	B	WEATHER	E	CVR TAPE TRANSCRIPTION			
	C	PHOTOGRAPHS	F	MAPS & CHARTS			

INVESTIGATION		
	ELAPSED TIME FROM ACCIDENT TO INVESTIGATOR'S ARRIVAL ON SCENE 2110 Hrs	ELAPSED TIME FROM ACCIDENT TO RECEIPT OF NOTIFICATION BY REGION 2111 Hrs

INVESTIGATORS' SIGNATURES

2112

SUPERVISORS' SIGNATURES

SUPERINTENDENT'S COMMENTS

23-0059 (2-84)

REGIONAL SUPERINTENDENT

DATE

APPENDIX 3

CASB Sample Computerized Accident Data Report

<---------- REPORT IDENTIFICATION ---------->

*FROM REGION : QUEBEC
*FILE NUMBER : 020035
*REPORT SUBMITTED : 11 FEB 83

LAST RECORD CHANGE : 23 JUNE 83

<---------- OCCURRENCE IDENTIFICATION ---------->

*A/C REGISTRATION : C-FJUM
*STATE OF REGISTRY : CANADA
*DATE : 26 MAY 82
*TIME : 19:10 LOCAL

LOCATION
* -NAME : LAC SEBASTIEN
* -PROVINCE : QUEBEC
* -CATA REGION : QUEBEC
* -LATITUDE : 48 39 N
* -LONGITUDE : 071 11 W
* -STATE/AREA : CANADA

<---------- PERSONNEL IDENTIFICATION ---------->

OPERATOR
-NAME : AIR SAGUENAY INC.
* -ATC LICENCE CLASS : 4 (CHARTER)
-TYPE : CHARTER

PILOT IN COMMAND
* -NAME : ?
-STATUS : EMPLOYEE

<---------- HISTORY OF THE FLIGHT ---------->

*OP'N AIR TRANSPT : NON-SCHEDULED DOMESTIC CARGO
LOAD DESCRIPTION : CARGO

*DEPARTED FROM : SAME AS LOCATION
*INTENDED LANDING AT : LAC LA SORBIERE

DEPARTURE BRIEFING : AIS AVAILABLE AND USED - INFO VALID
*FLIGHT PLAN/CLEARANCE OTHER
TYPE OF FLIGHT PLAN : FLIGHT NOTIFICATION VERBAL
DURATION OF FLIGHT : 0 HRS 04 MIN
AIRSPACE SEGMENT : ADVISORY AIRSPACE

<---------- HISTORY OF THE FLIGHT (CONTINUED)---------->

PHASE OF OPERATION
* -FIRST : ENROUTE/CLIMB TO CRUISE
-SECOND : FINAL TURN

ALTIT. OF OCCURR. : 46 M (151 FEET)

EMERGENCY CIRCUM. : UNUSUAL NOISE
SUSPECTED/KNOWN MECHANICAL DEFECT

FORCED LANDING : DITCHING
APPROACH FLOWN : VISUAL APP (NO AIDS)-CIRCLING
MILITARY INVOLVEMENT: NO

<---------- INJURIES TO PERSONS ---------->

*INJURY INDEX : FATAL

> > > > > NUMBER OF INJURIES < < < < <

PERSONNEL	FATAL	SERIOUS	MINOR	NONE	UNKNOWN	TOTAL
*PILOT	1					1
TOTAL CREW	1					1
PASSENGERS						0
*TOTAL ABOARD	1					1
*GRAND TOTAL	1					1

<---------- DAMAGE ---------->

*DAMAGE TO AIRCRAFT : SUBSTANTIAL

<---------- PERSONNEL INFORMATION ---------->

*PERSON AT CONTROLS : PILOT-IN-COMMAND

> > > PILOT < < < > > > COPILOT < < <

*NAME : ?

*AGE : 33

*SEX : MALE

STATION OCCUPIED : PILOT
SPECIAL FUNCTION : NONE

*LICENCE : COMMERCIAL

PERSONNEL INFORMATION (CONTINUED)

	> > > PILOT < < <	> > > COPILOT < < <
RATINGS		
* -CLASS	: MULTI ENGINE LAND MULTI ENGINE SEA	
-TYPE	: REQUIRED - NOT HELD	
-INSTRUCTOR	: NO	
-ENDORSEMENTS	: NIGHT	
LAST CHECK		
-ON TYPE	: 1 WEEKS	
FLIGHT HOURS		
* -TOTAL	: 3379	
* -ON TYPE	: 7	
LAST 3 DAYS	: 1	
LAST 30 DAYS	: 1	
LAST 90 DAYS	: 1	
LANDINGS ON TYPE		
-LAST 90 DAYS	: 2	
HOURS ON TYPE		
-LAST 90 DAYS	: 1	
-DUAL LAST 90 DAYS	: 1	
SINGLE ENGINE HOURS		
-TOTAL	: 3045	
-LAST 90 DAYS	: 1	
MULTI ENGINE		
-TOTAL	: 333	
THIS UNDERCARRIAGE		
-LAST 90 DAYS	: 1	
HOURS NIGHT		
-TOTAL	: 19	

MEDICAL,VALID/WAIVER: YES/WITHOUT

AIRCRAFT INFORMATION

SERIAL NUMBER	: 931
YEAR MANUFACTURED	: 56
*CLASSIFICATION	: AEROPLANE
*LANDING GEAR 1	: HULL/FLOAT
LANDING GEAR 2	: FLOAT
WING/ROTOR CONFIG.	: HIGH WING
AIRCRAFT WEIGHT	
* -MAXIMUM TAKE-OFF	: 5090 LBS
-CALCULATED AUW	: 4700 LBS
-RE AUTHORIZED	: AT OR BELOW AUTHORIZED
AIRFRAME TIME	
-TOTAL	: 1328 HRS
POWERPLANT(S)	
-MANUFACTURER	: PRATT & WHITNEY, UNITED STATES
-MODEL	: R-985 SERIES
* -NUMBER INSTALLED	: 1
* -TYPE OF POWER	: RECIPROCATING
-RATED POWER	: 450 HP
-FUEL TYPE	: 80/87 OCTANE AVGAS
PROPS/ROTOR BLADES	
-MANUFACTURER	: HAMILTON STANDARD
-PROP TYPE 1	: CONSTANT SPEED
TIME SINCE OVERHAUL	
-#1 ENGINE	: 5 HRS
AIRCRAFT EQUIPPED	
-TO MINIMUM IFR STD:	NO
STALL WARNING	
-SYSTEM	: NO WARN. INDICATOR/STICKPUSHER
COMMUNICATIONS	
-VHF	: INSTALLED - IN USE
-HF	: INSTALLED - NOT IN USE
OTHER ELECTRONICS	
-WEATHER RADAR	: NOT INSTALLED
ANTI-ICE/DE-ICE	
-ENGINE	: INSTALLED - NOT IN USE
ANTI-COLLN LIGHTS	: INSTALLED - NOT IN USE

<---------- AIRCRAFT INFORMATION (CONTINUED)--------->

IMPACT CONFIGURATION
- -LANDING GEAR : FIXED
- -FLAPS : PARTIAL
- -MIXTURE : RICH
- -CARB HEAT : COLD
- -INDUCTION HEAT : NOT INSTALLED

<---------- METEOROLOGICAL INFORMATION ---------->

WEATHER BRIEFING : FACILITIES AVAILABLE - NOT USED
BRIEFING AGENCY : NONE
WEATHER FORECAST : SUBSTANTIALLY CORRECT

LIGHT CONDITIONS : DAYLIGHT

> > > > WEATHER AT SITE OF OCCURRENCE < < < <

WIND
- -DIRECTION : 150 DEG MAGNETIC
- -SPEED : 7 KT
- -RELATIVE A/C TRACK: RIGHT HEAD WIND 023 - 067 DEG

VISIBILITY
* -AT SITE : ABOVE 10 KM (ABOVE 6 MILES)
* -RESTRICTION : ?

SKY CONDITION
* -AT SITE : SCATTERED BELOW 300 M (1 000 FEET)
* -CLOUD BASE AGL : 1676 M (5499 FEET)

*PRECIPITATION : ?

SIGNIFICANT WEATHER : OTHER

TEMPERATURES
- -IN CELSIUS : 27 DEG
- -DEWPOINT SPREAD : 16 DEG

ALTIMETER SETTING : 1012.9 MB (29.91 IN.)

GENERAL WEATHER : VMC

> > > > WEATHER AT FIRST OCCURRENCE < < < <

AIRCRAFT ALTITUDE : 244 M (801 FEET)
AIRCRAFT HEIGHT AGL : 30 M (98 FEET)

TEMPERATURES
- -IN CELSIUS : 27 DEG
- -DEWPOINT SPREAD : 16 DEG

<---------- WRECKAGE AND IMPACT INFORMATION ---------->

WRECKAGE RECOVERED : YES

TERRAIN
- -SURFACE-GENERAL : WATER
- -SURFACE-SPECIFIC : OTHER

FIRST IMPACT
- -ELEVATION : 11 M (36 FEET)

AIRCRAFT ATTITUDE	> > AT IMPACT < <	> > AT REST < <
-ROLL	: 30 DEG LEFT ROLL	90 DEG RIGHT ROLL
-PITCH	: 30 DEG NOSE DOWN	0 DEG LEVEL
-YAW	: 0 DEG ZERO YAW	0 DEG ZERO YAW

AERODROME
- -PROXIMITY : WITHIN 1.2 KM
- -DIRECTION : 170 DEG MAGNETIC

OFF AERODROME AREA
- -LENGTH : 3048 M (10000 FEET)
- -WIDTH : 213 M (699 FEET)

<---------- AERODROME INFORMATION ---------->

AERODROME
- -NAME : LAC SEBASTIEN
- -TYPE : LAND

<---------- SURVIVAL DATA ---------->

SURVIVABILITY : NON SURVIVABLE

POST CRASH ESCAPE : NOT APPLICABLE

OCCUPANTS
- -EVACUATED : 0
- -NOT EVACUATED : 1

IMPACT DAMAGE
- -A/C WITH NO CABIN : SEVERE
- -COCKPIT : MODERATE
- -FORWARD CABIN : MINOR
- -CENTRE CABIN : MINOR
- -AFT CABIN : MINOR

SEATS
- -CONFIGURATION : FORWARD FACING

<----------- SURVIVAL DATA (CONTINUED) ----------->

SHOULDER HARNESS
- -PILOT : NOT INSTALLED
- -COPILOT : NOT INSTALLED

PILOT'S SEAT BELT : FAILED

EVACUATION
- -ASSISTANCE : NOT REQUIRED
- -CHUTE/SLIDE : NOT AVAILABLE
- -ROPE : NOT AVAILABLE
- -LADDER : NOT AVAILABLE
- -EMERGENCY LIGHTS : NOT AVAILABLE

DITCHING
- -COND'NS/INTEGRITY : SHELTERED AREA-CALM-A/C BROKE UP
- -A/C SANK/FLOATED : SANK IMMEDIATELY (NO EVACUATION)

<----------- INVESTIGATION ----------->

NO. INVESTIGATORS
- -CAI : 1

ASSISTANCE
- -DNHW : YES
- -ASE : YES
- -OTHER : NO

INVESTIGATED BY
- -CORRESPONDENCE : NO

APPENDED DOCUMENTS
- -INTERVIEWS : EYEWITNESS
  MAINTENANCE PERSONNEL
  SPOUSE
- -REPORTS : PATHOLOGIST
- -OPERATIONAL DATA : WEATHER
  PHOTOGRAPHS
  MAPS AND CHARTS

ENQUETEUR(S)
- -NAME : Y. GOSSELIN

HW ANALYST
- -NAME : J. LEROUX

<----------- NARRATIVE ----------->

ABOUT 4 MIN AFTER TAKE-OFF, THE PILOT RADIOED THAT HE WAS RETURNING TO BASE BECAUSE OF HIGH CYLINDER HEAD TEMPERATURES. A FEW SECONDS LATER, THE ENGINE LOST POWER. DURING THE FINAL TURN TO THE LAKE, THE LEFT WING STRUCK TREE TOPS; CONTROL WAS LOST AND THE A/C CRASHED INTO THE WATER. THE PILOT HAD NOT FLOWN FOR 6 MONTHS, AND THIS WAS HIS FIRST OPERATIONAL FLIGHT OF THE SEASON.

TECHNICAL EXAMINATION CONFIRMED THE INTEGRITY OF THE FLIGHT CONTROLS AND SURFACES. LABORATORY EXAMINATION OF THE ENGINE AND COMPONENTS REVEALED SEVERAL DISCREPANCIES, NONE OF WHICH WOULD HAVE CAUSED THE ENGINE TO FAIL. THESE INCLUDED 2 UNSERVICEABLE PUSHRODS, 2 SPARK PLUGS, 1 MAGNETO, AND A CRACKED PISTON. THE CARBURETTOR WAS FUNCTIONALLY TESTED AND FOUND SERVICEABLE, BUT THE TEST FIGURES SHOWED AN EXCESSIVELY LEAN CONDITION. THIS COULD HAVE BEEN THE CAUSE OF THE HIGH CYLINDER HEAD TEMPERATURES. (LP 167/82, LP 175/82, AND STANDARD AERO REPORT REFER).

THE ENGINE-DRIVEN FUEL PUMP WAS TESTED AND FOUND TO BE INOPERATIVE, AND THEREFORE PROBABLY CAUSED THE ENGINE FAILURE. THE PUMP WAS DISMANTLED FOR INTERNAL INSPECTION, BUT NO DISCREPANCIES WERE NOTED. IN FACT, AFTER REASSEMBLY, THE PUMP FUNCTIONED NORMALLY. NO REASON COULD BE FOUND FOR THE UNSERVICEABILITY DURING THE INITIAL TESTING (LP 167/82 REFERS).

<----------- FACTORS ----------->

<A> RELATED TO FIRST OR ONLY TYPE OF OCCURRENCE

01 POWERPLANT:
FUEL SYS-RECIPROCATING/PUMPS
02 -SPECIFICALLY:
FAILURE/FAILED

03 OTHER PERSONNEL:
MAINT SERV PERS/INADEQUATE MAINT/INSPECTION

<B> RELATED TO SECOND TYPE OF OCCURRENCE

01 PILOT:
LACK OF FAMILIARITY WITH A/C

02 PILOT:
ENCOUNTERED UNFORSEEN CIRCUMSTANCES BEYOND CAPABILITY

APPENDIX 4

CASB Crashworthiness Supplementary Form

CRASHWORTHINESS—KINETICS

INITIAL VELOCITIES

HORIZONTAL ft/sec
2201

FLIGHT PATH ft/sec

VERTICAL ft/sec
2202

☐ VERIFIED ☐ ESTIMATED
2203

FLIGHT PATH ANGLE & TERRAIN ANGLE

A °
2204

A HORIZON

T

T °
2205

☐ VERIFIED ☐ ESTIMATED
2206

IMPACT ANGLE & ATTITUDE

C °

C HORIZON

B °
2207

2200

OPEN TERRAIN (Select up to two)

A	CONCRETE	G	FRESH LOOSE SNOW
B	ASPHALT	H	DRY CULTIVATED SOIL
C	DRY PACKED CLAY	K	WET CULTIVATED SOIL
D	DRY SOD	L	BOGGY
E	WET SOD	M	WATER
F	PACKED SNOW	N	ICE
Y	OTHER		

2209

OBSTACLES (Select up to three)

A	ROCK FACE	H	TREES 6" TO 9" DIA.
B	RIGID STRUCTURE	K	TREES 9" TO 12" DIA.
C	WOOD FRAME STRUCTURE	L	TREES 12" DIA. +
D	BOULDERS 0.5 TO 1.0 FT DIA.	M	SCRUB TREES
E	BOULDERS 1 TO 2 FT DIA.	N	WIRES
F	BOULDERS 2 TO 3 FT DIA.	P	POLES
G	TREES 3" TO 6" DIA.	Y	OTHER

WATER DEPTH ft 2210	SURFACE SLIDE	SLIDING DISTANCE ft	HORIZONTAL G (COEFF FRICTION)	LATERAL VELOCITY ft/sec 2213/2214	DIRECTION
ICE THICKNESS ft 2211		HORIZONTAL VELOCITY CHANGE ft/sec	SLIDE TIME sec		L LEFT R RIGHT

MOST SEVERE IMPACT

PULSE TYPE

A☐ B☐ C☐ D☐ E☐

2212

INITIAL VELOCITY Vo	ft/sec	VERT. VELOCITY CHANGE (Vo-Vf) Vv	ft/sec
FINAL VELOCITY Vf	ft/sec	HORIZ. VELOCITY CHANGE (Vo-Vf) Vh	ft/sec
FLIGHT PATH ANGLE θ_{Fp}	deg.	VERTICAL DECEL. Gv	G
REBOUND ANGLE θ_{FB}	deg.	HORIZONTAL DECEL. Gh	G
VERTICAL Crush (1) ____ Stop Dist. (2) ____ (1 + 2) Sv ____	ft	RESULTANT DECEL. Gr	G
		RESULTANT FORCE ANGLE θ_G	deg.
HORIZONTAL Crush (1) ____ Stop Dist. (2) ____ (1 + 2) Sh ____	ft	VERTICAL PULSE DURATION VT	Sec
		HORIZONTAL PULSE DURATION HT	Sec

SECOND MOST SEVERE IMPACT

PULSE TYPE

A☐ B☐ C☐ D☐ E☐

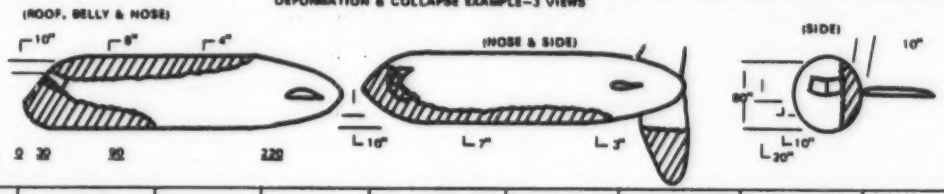
2223

INITIAL VELOCITY Vo	ft/sec	VERT. VELOCITY CHANGE (Vo-Vf) Vv	ft/sec
FINAL VELOCITY Vf	ft/sec	HORIZ. VELOCITY CHANGE (Vo-Vf) Vh	ft/sec
FLIGHT PATH ANGLE θ_{Fp}	deg.	VERTICAL DECEL. Gv	G
REBOUND ANGLE θ_{FB}	deg.	HORIZONTAL DECEL. Gh	G
VERTICAL Crush (1) ____ Stop Dist. (2) ____ (1 + 2) Sv ____	ft	RESULTANT DECEL. Gr	G
		RESULTANT FORCE ANGLE θ_G	deg.
HORIZONTAL Crush (1) ____ Stop Dist. (2) ____ (1 + 2) Sh ____	ft	VERTICAL PULSE DURATION VT	sec
		HORIZONTAL PULSE DURATION HT	sec

CRASHWORTHINESS—DEFORMATION

FUSELAGE INWARD COLLAPSE OR DEFORMATION

DEFORMATION & COLLAPSE EXAMPLE—3 VIEWS



FUSELAGE AREA	INWARD DEFORMATION (in inches)	STATION NO. FROM	STATION NO. TO	FUSELAGE AREA	INWARD DEFORMATION (in inches)	STATION NO. FROM	STATION NO. TO	FUSELAGE AREA	INWARD DEFORMATION (in inches)	STATION NO. FROM	STATION NO. TO
a. ROOF				c. LEFT SIDE				e. BELLY			
								f. NOSE			
b. FLOOR				d. RIGHT SIDE							
								g. REAR			

MAJOR COMPONENT DISPLACEMENT

COMPONENT	DISPLACEMENT IN INCHES						ENTERED COCKPIT	ENTERED PASSENGER AREA
	UP	DOWN	FWD	AFT	LEFT	RIGHT		
ENGINE 1								
ENGINE 2								
ENGINE 3								
ENGINE 4								
PROP 1								
PROP 2								
PROP 3								
PROP 4								
LEFT WING								
RIGHT WING								
MAIN ROTOR								
FORWARD ROTOR								
AFT ROTOR								
TRANS. MAIN								
TRANS. FWD								
TRANS. AFT								
OTHER								

LANDING GEAR DEFORMATION

GEAR LOCATION	PERMANENT DEFORMATION IN INCHES						BROKEN	TORN FREE
	UP	DOWN	FWD	AFT	LEFT	RIGHT		
LEFT FRONT								
RIGHT FRONT								
LEFT REAR								
RIGHT REAR								
CENTRE FRONT								
CENTRE REAR								

NOTES:

CRASHWORTHINESS—SYSTEMS & PROCEDURES

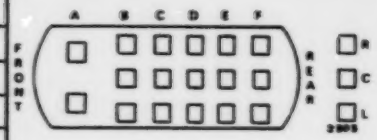
SYSTEM/ PROCEDURE GENERAL	SYSTEM/PROCEDURE SPECIFIC	NEEDED	ON BOARD OR AVAILABLE			USED/ WORN			PRODUCED/ CONTRIB. TO INJURIES			MINIMIZED/ PREVENTED INJURIES			FAILED		
			YES	NO	?	YES	NO	?	YES	NO	?	YES	NO	?	YES	NO	?
RESTRAINT SYSTEM CREW	LAP BELT 2401/2402																
	SHOULDER HARNESS 2403/2404																
	LAP BELT TIE DOWN STRAP 2405/2406																
	INERTIA REEL 2407/2408																
	SHOULDER STRAP GUIDE 2409/2410																
RESTRAINT SYSTEM PASSENGERS	LAP BELT 2411/2412																
	SHOULDER HARNESS 2413/2414																
	LAP BELT TIE DOWN STRAP 2415/2416																
	INERTIA REEL 2417/2418																
	SHOULDER STRAP GUIDE 2419/2420																
SEATS	SEAT/PILOT 2421/2422																
	SEAT/COPILOT 2423/2424																
	SEAT/JUMP 2425/2426																
	SEAT/PASSENGER 2427/2428																
IMMEDIATE ENVIRONMENT COCKPIT	DESIGN 2429/2430																
	LOCATION 2431																
	RESTRAINT 2432/2433																
IMMEDIATE ENVIRONMENT CABIN	DESIGN 2434/2435																
	LOCATION 2436																
	RESTRAINT 2437/2438																
CABIN BAGGAGE	LOCATION 2439																
	RESTRAINT 2440/2441																
CARGO	LOCATION 2442																
	RESTRAINT 2443/2444																
EMERGENCY EVACUATION	AIRCRAFT DOORS 2445/2446																
	EMERGENCY EXITS 2447/2448																
	CHUTES 2449/2450																
	ROPES 2451/2452																
	EXIT LIGHTING 2453/2454																
	INTERIOR EMERGENCY LIGHTING 2455/2456																
	SUPERVISION 2457/2458																
	WARNING 2459/2460																
	OTHER 2461/2462																
WATER LANDINGS	LIFE VESTS—ACCESSIBILITY 2463/2464																
	LIFE VESTS—TYPE 2465/2466																
	LIFE RAFTS—ACCESSIBILITY 2467/2468																
	LIFE RAFTS—TYPE 2469/2470																

CRASHWORTHINESS–INJURIES

IDENTIFICATION 2901	
A	PILOT
B	CO-PILOT
C	OTHER FLIGHT CREW
D	CABIN CREW
E	PASSENGER
F	PERSON OUTSIDE AIRCRAFT

DEGREE OF INJURY 2902	
F	FATAL
S	SERIOUS
M	MINOR
N	NONE

AUTOPSY 2903	
A	PHYSICIAN
B	PATHOLOGIST
C	FLIGHT SURGEON
D	OTHER
E	CAML PRESENT



ROW _____ 2904

FACING 2906	
F	FRONT
S	SIDE
R	REAR

THERE IS SPACE BELOW FOR SPECIFYING UP TO TEN INJURIES FOR THE PERSON COVERED BY THIS PAGE. THE "EIGHTH REVISION, INTERNATIONAL CLASSIFICATION OF DISEASES, SECTION XVII WILL BE USED TO CATEGORIZE ALL INJURIES.

ENTER THE PROPER CODE IN THE SPACE PROVIDED AS WELL AS A NARRATIVE DESCRIPTION OF THE INJURY.

ENTER THE APPROPRIATE CODE FOR THE "EVENT CAUSING INJURY" AT THE RIGHT.

EVENT CAUSING INJURY	
STRUCK INTERIOR OF AIRCRAFT AT IMPACT	A
STRUCK BY FLYING OBJECT INSIDE AIRCRAFT	B
BURNS ONLY	C
BURNS FOLLOWING OTHER INJURIES	D
CRUSHED IN WRECKAGE	E
CONTACT WITH PROP/INTAKE/EXHAUST	F
FELL FROM AIRCRAFT (OR THROWN)	G
STRUCK BY AIRCRAFT	H
PULLED UNDERWATER	J
STRUCK BY MAIN ROTOR	K
STRUCK BY TAIL ROTOR	L
STRUCK INTERIOR OF AIRCRAFT IN TURBULENCE	M
STRUCK BY DISPLACED COMPONENT/STRUCTURE	N

	CODE	
2907		2908
2909		2910
2911		2912
2913		2914
2915		2916
2917		2918
2919		2920
2921		2922
2923		2924
2925		2926

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